Energy Use In Canada In Comparison With Other Countries

Z. Charles Slagorsky

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Preface

I should like to thank those who assisted me in the preparation of this study: Barbara Green and Catherine Szata for their research assistance at different phases of the work; two anonymous referees and Tony Ellison for comments and helpful criticisms; John Dawson for his continuous encouragement and useful advice; and finally to Yvonne Ellingson and Barbara Lees for their very patient work in preparing the various drafts. I alone remain responsible for any errors or omissions.

Chapter 1

INTRODUCTION

In bringing energy needs and energy availability into balance there are two sides: energy demand and energy supply. While a rising demand for energy might be met by expanding supplies, this comes at extra cost. The capital expenditures associated with providing additional energy supplies are substantial, and increasing. The implications are for even higher prices paid by energy consumers. An alternative approach is to slow the growth of demand, to hold it constant or even to reverse the trend through energy conservation measures. Within limits, it is generally possible to substitute other resources for energy and hence use energy for the same purpose but more efficiently.

Recent international comparisons of energy utilization reveal that Canada's consumption of energy is higher than that of other industrial countries, a fact well demonstrated by the figures in Tables 1.1 and 1.2 and in Figure 1.1. This in turn brought about insinuations that in Canada (and the U.S. as well) energy is being used 'wastefully'.

In a recent statement pertaining to opportunities for energy saving, the Federal Minister of Energy, Mines and Resources suggested that it is "...the residential, commercial, industrial and transport sectors, where we [in Canada] are indulging in wasteful energy-use habits fostered by relatively cheap energy over the past few decades."[1] In the United States too, similar statements have been made: "...with only 6 percent of the world population, we [in the U.S.] use 35 percent of the world's energy, and not merely because U.S. society is so highly developed. Fully 30 percent of our energy use is pure waste."[2] In a recent speech, Dr. Sylvia Ostry, the Chairman of the Economic Council of Canada, remarked that the area of efficient energy utilization is where investment activity is urgent and where additional research and development work will pay extra dividends. She observed that "...relative to the U.S., we in this country use more energy per unit of output. Therefore, any energy saving we can achieve will have even greater beneficial effects here, and the consequences of <u>not</u> conserving, will be more damaging."[3] And in the most recent statement, the Canadian Prime Minister, Rt. Hon. Joseph Clark, said at a news conference following the Tokyo economic summit that "Canadians

TABLE 1.1

INDEX OF ENERGY CONSUMPTION PER CAPITA, 1970-1976
CANADA = 100

Country	1970	1971	1972	1973	1974	1975	1976
Canada	100	100	100	100	100	100	100
United States	104	104	98	99	95	90	95
Japan	37	37	35	37	37	35	36
France	40	41	38	42	40	37	39
West Germany	53	52	49	51	50	46	49
Italy	30	29	28	29	29	27	28
Netherlands	51	51	53	54	53	51	55
Sweden	75	73	67	69	65	67	71
United Kingdom	52	50	47	48	45	43	43

SOURCE: OECD, OECD Economic Surveys, Paris, 1977.
OECD, Energy Balances of OECD Countries, Paris, 1974 and 1977 Editions.

TABLE 1.2

INDEX OF ENERGY CONSUMPTION PER DOLLAR OF GROSS DOMESTIC PRODUCT, 1970-1976
(MTOE[a] per constant U.S. 1970 dollar of GDP, CANADA = 100)

Country	1970	1971	1972	1973	1974	1975	1976
Canada	100	100	100	100	100	100	100
United States	86	87	82	84	85	82	85
Japan	77	75	70	72	74	70	72
France	57	57	54	60	57	53	55
West Germany	68	68	65	69	69	64	68
Italy	68	68	67	70	69	67	70
Netherlands	83	84	89	92	89	86	94
Sweden	72	73	68	73	68	70	76
United Kingdom	94	92	87	86	87	84	85

SOURCE: OECD, National Accounts of OECD Countries, Paris, 1976, p. 132.
OECD, Energy Balances of OECD Countries, Paris, 1976 and 1978 editions.

NOTES: [a]Millions of tons of oil equivalent.

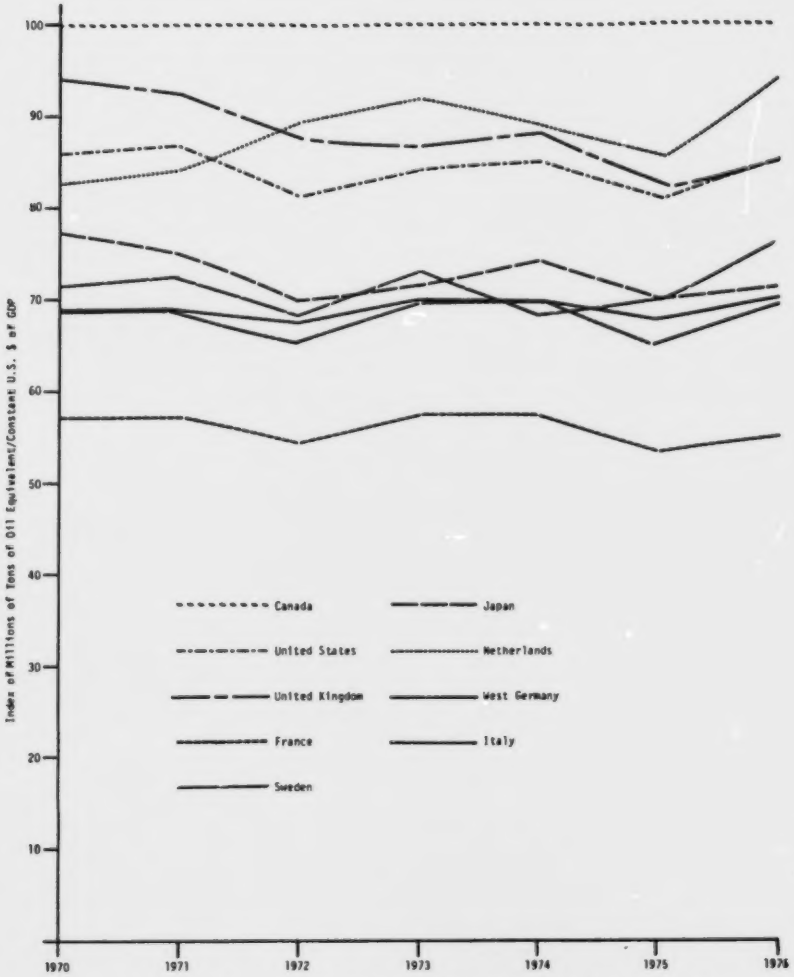

FIGURE 1.1: Index of Energy Consumption per Constant Dollar of Gross Domestic Product, 1970 - 76. (millions of tons of oil equivalent/constant U.S. dollar of GDP, Canada = 100)

SOURCES: OECD, National Accounts of OECD Countries, Paris, 1976.
OECD, Energy Balances of OECD Countries, Paris, 1976 edition.

are wasteful users of energy and conservation will have to become a must."[4]

Remarks such as these call for a closer inquiry for they suggest that Canada and the U.S. needlessly consume more energy per unit of output than other industrial countries. If this is so, then a potential for conservation of energy in Canada should exist and if realized, the present rate of use of energy could be slowed down. This would have the desirable effect of postponing the date when the relatively cheap conventional energy sources will be depleted, providing more time for the development of Canada's more expensive energy resources such as the heavy oils, tar sands, tidal power or solar energy.

To different people conservation of energy may mean different things. It is possible to talk about conservation of the environment, natural resources, soil conservation, the conservation of energy, fisheries, forests, etc. The general meaning of the word 'conservation' (see Webster dictionary) is simply a careful protection, management or preservation of something with an overriding objective to prevent undue exploitation or plain destruction.

The focus of attention in this study will be on the question of whether or not Canada is a high and wasteful user of energy and hence whether any conservation potential exists and can be exposed. An investigation into such a question must begin by making it clear what is meant by conservation of energy or more generally by conservation of natural resources such as crude oil, natural gas, coal, etc. Although a rather frequent reference to the term 'energy conservation' can be found in the media and in literature, it is seldom well defined. This in turn causes not only confusion but, when undefined, 'conservation', like morality, becomes what everyone is for and no one against.

Once a workable definition of energy conservation has been provided, an international comparison of energy use will be adopted to suggest where in Canada the potential to conserve energy may be and whether or not, relative to other countries, Canada is using resources wastefully. A third objective will be to see what, if anything, Canada can learn from other countries through international comparisons of energy utilization.

In attempting to realize the stated objectives, the present inquiry will adopt similar methodology to that employed by Joel Darmstadter et al. in their comparative analysis,[5] but it will look closer at Canada, provide more up-to-date information and the comparisons of energy use between countries will be made for one recent year as well as over a longer time period.

Footnotes

[1]Canada, Department of Energy, Mines and Resources, Energy Conservation in Canada, Foreword by The Honourable A. Gillespie, Minister of Energy, Mines and Resources (Ottawa: Supply and Services Canada, 1977), Report EP 77-7, p. iii.

[2]J.C. Sawhill, remarks at 'Project Independence' Hearing, San Francisco, 1974, cited by J. Darmstadter, J. Dunkerley, and J. Alterman, How Industrial Societies Use Energy, (Baltimore: The Johns Hopkins University Press published for Resources for the Future, 1977), pp. 8-9.

[3]S. Ostry, "On the Other hand...," a speech given to the Canadian Club in Toronto, December 4, 1978, pp. 13-14 (Mimeographed.)

[4]CFCN Radio Calgary, Newscast, June 29, 1979, 4:30 PM.

[5]J. Darmstadter, J. Dunkerley, and J. Alterman, How Industrial Societies Use Energy, (Baltimore: The Johns Hopkins University Press published for Resources for the Future, 1977), pp. 8-9.

Chapter 2

CONSERVATION AND THE RATIO OF ENERGY TO OUTPUT

To be operational, a definition of conservation must enable us to quantitatively assess two different ways of using energy in production or consumption.[1] The definition must allow monitoring of the various intensities of energy use[2] which may be referred to as different states of conservation. One possiblility is to define conservation as the declining use of energy relative to output. More precisely, this can be expressed in terms of a declining use of the energy input (E) per capita or per monetary value of output, usually the gross domestic product (GDP). Since the E/GDP ratio ties the usage of energy with economic activity, this ratio must be considered a superior measure of the intensity of energy use than the simple ratio of energy per capita. Then, for example, if the E/GDP ratio of country A is found greater than that of country B, country A can be said to conserve less energy relative to B. This means that if now country A sets for itself a goal of reaching B's value of the E/GDP ratio (i.e., conserve more energy), it will be aiming at 'a moving target' since also B's E/GDP ratio may change through time. Alternatively, it should be noted that the ratio of energy to output is the reciprocal of the ratio expressing energy productivity (GDP/E). Hence a declining energy/output ratio, or conservation as defined here, also implies a rising productivity of the energy input.

Although very simple and useful for the present purpose, the ratio of energy to output has its shortcomings. A brief investigation into the determining factors will help to reveal the more important drawbacks as well as to make clear the suggested function of the ratio in monitoring the different states of conservation.

When considering the intensity of energy use in any country, it must be realized that factors other than the price of energy will determine its quantity demanded, although price remains the single most important factor. The more significant among the other determinants are the following:

(i) the climate;

(ii) the geography of a given country or region;

(iii) the density of population;

(iv) the composition of GDP which may include highly energy-intensive goods requiring a greater quantity of energy to produce (e.g., aluminum or refined petroleum products);

(v) the prices of other factors of production used (capital, labour);

(vi) exchange rates and the volume of international trade; and

(vii) technological factors, such as the level of technology employed and its nature.

Ideally, a comparative study of energy utilization should account for all of these, and possibly other factors that may affect the numerical value of the E/GDP ratio before any 'hard' conclusions are drawn. Because this is impossible, results of any comparative analysis must be interpreted with great caution after as many as possible of the above determining factors have been taken into consideration and, if possible, accounted for.

Economic theory assumes that the quantity demanded of a given commodity increases as its price declines. With the selling price determined on the market by the interplay of supply and demand, a price of a natural resource in a given country will be affected in an important way by that country's endowment (i.e., supply) of the resource. A country possessing rich deposits of energy resources will then be said to have a comparative advantage in energy over other countries not so endowed and, due to the more abundant supply, the prices of energy products should generally be lower. Since energy is only one of the factors of production, and a relatively minor one, the possibility of factor substitution will generally exist, at least to some extent, over the long-run. Therefore a country like Canada, for example, possessing relatively abundant energy resources would be expected to show historically lower prices of energy when compared with other countries; and the Canadian E/GDP ratio should be found correspondingly higher. Tables 2.1 to 2.6 show the historical price developments of several key energy products for a wider group of selected industrial countries. It will be noted that the prices of these energy products in Canada are the lowest or rank always among the lowest and, as Table 2.7 shows, the Canadian E/GDP ratio was the highest in 1976 for a similar group of nations. Thus an important, though foreseen relationship between energy prices and the energy output ratio appears verified: historically low energy prices will tend to increase the use of energy relative to other factor inputs. This in turn reflects itself in lowering the productivity of energy or increasing the energy/output ratio. It should also be noted that in the case of both electricity and natural gas, industrial users pay a lower price per unit than

TABLE 2.1

INLAND TRANSPORT - REGULAR GASOLINE
(Average prices paid in main consuming areas at 1st January of each year)

Country	Prices In U.S. $/100 litres								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	9.1	10.0	10.1	10.4	10.4	10.4	12.9	14.0	17.4
United States	9.0	8.8	9.2	9.9	9.8	10.5	11.5	14.6	15.7
Japan	15.0	14.3	12.5	10.7	13.5	17.1	28.0	36.1	36.6
France	19.5	20.9	18.9	19.1	19.8	23.9	33.9	37.8	39.0
Germany	15.4	14.8	15.1	15.5	16.1	21.3	28.1	34.2	32.5
Italy	19.2	19.2	20.8	24.3	24.3	25.8	30.4	43.0	45.6
Netherlands	14.8	15.6	15.7	17.5	19.2	24.6	30.1	37.6	38.2
Sweden	17.0	16.8	16.4	18.7	19.2	21.7	26.4	34.0	34.9
United Kingdom	14.2	15.6	15.7	17.5	19.2	24.6	30.1	37.6	38.2
Austria	12.9	12.9	12.9	12.9	14.4	17.1	24.7	33.9	31.3
Belgium	17.2	17.0	17.4	18.5	18.4	25.2	27.4	37.9	36.9
Ireland	14.8	15.3	15.8	16.8	17.2	19.2	24.6	32.6	32.8
Norway	16.7	16.9	17.4	20.4	22.4	23.6	32.3	38.9	38.1
Spain	13.7	13.7	13.6	13.6	14.7	18.1	20.2	31.1	32.5
Switzerland	14.3	13.9	13.7	13.9	16.5	18.0	22.6	37.3	36.3

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 190.

NOTE: Whenever the price of a given output is stated in a common currency unit, an additional problem is introduced by using exchange rates. Since the exchange rate between any two currencies is determined only by the respective foreign sectors of the two countries, the actual purchasing power of either currency may be under or overstated. Differential rates of domestic inflation in two countries will exert a similar distorting effect onto the exchange rates. Caution must therefore be exercised in interpreting the results.

TABLE 2.2

INDUSTRIAL NATURAL GAS
(Average prices paid in main consuming areas at 1st January)

Country	Prices In U.S. $/10^7 Kcal [T.O.E.]								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada[a]	14.0	14.7	15.0	15.4	16.1	16.8	19.8	27.0	39.0
United States	14.0	13.5	44.5	45.2	47.6	48.5	53.0	69.0	72.5
Japan	-	-	-	-	-	-	-	-	-
France	51.0	59.9	49.9	50.3	56.3	74.1	87.0	123.5	122.5
Germany	-	-	-	-	-	-	-	-	-
Italy	22.0	22.4	24.8	24.8	22.9	26.0	24.5	60.0	80.0
Netherlands	25.0	26.5	26.5	26.5	28.1	34.9	48.0	80.0	93.0
Sweden	-	-	-	-	-	-	-	-	-
United Kingdom	b	b	58.5	58.5	63.6	75.9	71.5	113.2	118.5
Austria	27.0	40.8	40.8	42.7	54.0	56.8	76.7	197.0	169.0
Belgium	49.0	51.4	53.0	56.4	58.2	70.8	80.0	107.0	130.0
Ireland	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-
Spain	-	-	-	-	-	-	-	-	-
Switzerland	-	-	-	-	-	-	-	-	-
						109.2	129.0	206.5	200.5

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 180.

[a]National average referring to the month of December of the preceding year.

[b]Sales of natural gas are insufficiently developed to warrant price quotations. 1970 = 100.

TABLE 2.3

DOMESTIC (HOUSEHOLD) NATURAL GAS
(Average prices paid in main consuming areas at 1st January)

Country	Prices in U.S. $/10^7 Kcal [T.O.E.]								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada[a]	39.0	35.0	36.0	35.0	35.0	37.0	39.0	46.0	56.5
United States	45.0	41.0	76.0	99.0	101.0	81.0	88.0	111.0	116.0
Japan	-	-	-	-	-	-	-	-	-
France	142.0	166.5	144.5	157.5	168.5	212.5	220.5	321.5	318.5
Germany	130.0	135.0	147.5	147.5	160.5	199.5	214.5	284.5	310.5
Italy	56.0	56.0	56.0	56.0	70.0	75.0	70.4	66.0	122.5
Netherlands	83.0	84.0	84.0	84.0	87.0	108.0	116.0	158.0	157.0
Sweden	-	-	-	-	-	-	-	-	-
United Kingdom	b	106.0	114.5	114.5	129.0	146.5	141.0	165.5	164.0
Austria	82.0	74.0	74.0	67.0	71.0	93.0	132.0	179.0	178.0
Belgium	153.0	145.0	149.0	175.0	182.0	238.0	248.0	326.5	320.5
Ireland	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-
Spain	105.0	96.0	105.0	118.0	145.0	178.0	183.0	185.0	227.0
Switzerland	-	-	-	-	-	-	-	-	-

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 173.

[a]National average referring to the months of December of preceding year.

[b]Sales of natural gas are insufficiently developed to warrant price quotations, 1969 = 100.

TABLE 2.4

DOMESTIC (HOUSEHOLD) ELECTRICITY
(Average prices paid in main consuming areas at 1st January)

Country	Prices in U.S. $/10^7 Kcal [T.O.E.]								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	216.5	216.5	216.5	219.5	285.0	319.5	345.5	380.0	539.0
United States	-	-	-	-	-	-	-	-	-
Japan	421.0	418.0	449.0	449.0	449.0	512.0	577.0	633.5	629.5
France	371.5	369.5	339.0	354.0	396.0	499.0	508.5	686.0	679.0
Germany	-	-	-	-	-	-	-	-	-
Italy	456.0	378.5	384.5	384.5	384.0	395.0	371.5	608.5	765.0
Netherlands	228.0	248.5	247.0	272.5	284.0	379.5	426.5	620.0	698.5
Sweden	247.0	238.5	238.5	244.5	244.5	276.0	273.0	361.5	443.0
United Kingdom	254.0	254.0	254.0	272.5	298.5	339.5	324.0	426.0	494.5
Austria	318.0	276.5	226.0	226.0	237.0	468.0	496.0	699.5	695.5
Belgium	397.0	391.5	383.5	424.5	427.5	497.0	544.0	843.0	802.0
Ireland	198.0	217.5	230.5	236.0	276.0	330.0	382.0	531.0	524.0
Norway	210.0	210.0	153.0	251.0	265.0	326.0	358.0	474.0	443.0
Spain	299.0	299.0	372.0	391.0	391.0	493.0	514.0	603.0	692.0
Switzerland	269.0	269.0	248.5	271.5	289.0	414.5	429.5	547.0	583.5

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 172.

TABLE 2.5

INDUSTRIAL ELECTRICITY
(Average prices paid in main consuming areas at 1st January)

Country	Prices in U.S. $/10^7 Kcal [T.O.E.]								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	87.0	88.6	94.0	100.4	102.3[a]	81.8	88.9	100.3	116.0
United States	-	-	-	-	-	-	-	-	-
Japan	144.0	141.6	154.8	154.4	154.8	176.7	198.9	324.4	323.0
France	158.0	162.5	144.1	147.7	155.0	194.1	196.6	285.5	385.5
Germany	-	-	-	-	-	-	-	-	-
Italy	178.0	179.0	179.1	178.6	179.0	181.9	172.1	273.8	361.5
Netherlands	151.0	154.1	152.4	175.6	184.1	198.8	263.5	375.0	435.0
Sweden	95.0	106.6	97.6	103.6	104.3	129.6	140.8	232.0	257.5
United Kingdom	157.5	159.9	162.2	169.8	182.8	206.9	203.6	306.5	329.0
Austria	190.0	167.9	212.1	211.6	223.2	293.5	310.6	377.3	366.4
Belgium	162.0	162.8	153.5	194.9	190.7	203.5	251.3	437.2	427.0
Ireland	128.0	144.2	143.0	144.8	150.9	177.9	252.4	363.9	358.0
Norway	78.0	78.1	100.9	94.2	110.0	132.5	144.3	200.0	187.0
Spain	124.5	124.6	135.1	136.4	136.7	173.8	191.9	225.0	295.5
Switzerland	150.0	139.7	140.3	125.1	136.6	175.5	220.4	280.8	297.0

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 178.

NOTES: Data for Canada have been calculated on the basis of Statistics Canada, Electric Power Statistics, Catalogue 57-202, Tables 3 and 5, various years.

[a]Up to and including 1972, the statistics used included small (less than 5 MW) users generally paying higher price for electricity. Beyond 1972, only users over 5 MW annually are included.

TABLE 2.6

POWER STATIONS - HEAVY FUEL OIL
(Average prices paid in main consuming areas at 1st January)

Country	Prices in U.S. $/10^7 Kcal [T.O.E.]								
	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	14.0	14.0	14.0	12.8	11.7	14.1	15.3	18.1	28.9
United States	14.0	13.1	12.6	14.5	20.4	25.1	48.9	75.6	78.5
Japan	16.5	16.2	16.9	17.1	19.2	23.8	43.1	71.1	80.5
France	23.0	21.3	15.8	17.7	16.6	20.0	41.4	54.0	
Germany	-	-	-	-	-	-	-	-	-
Italy	17.0	18.3	16.9	21.7	22.7	24.4	35.1	63.05	76.1
Netherlands	17.0	16.2	15.1	26.7	17.4	22.9	32.2	84.0	72.3
Sweden	12.5	10.3	16.0	26.5	13.8	18.9	33.5	77.4	75.2
United Kingdom	19.0	17.8	18.1	27.1	28.7	29.3	37.7	84.6	78.3
Austria	20.0	20.0	20.0	23.2	31.4	36.2	38.9	88.2	75.9
Belgium	27.0	23.8	25.4	26.7	29.0	23.0	41.2	80.7	65.2
Ireland	16.0	12.5	12.1	14.4	17.0	19.5	45.5	66.5	64.3
Norway	-	-	-	-	-	-	-	-	-
Spain	19.0	18.0	18.9	18.0	24.5	26.0	27.5	43.1	70.1
Switzerland	-	-	-	-	-	-	-	-	-

SOURCE: OECD, Energy Statistics, Paris, 1978, p. 187.

TABLE 2.7

ENERGY/OUTPUT RELATIONSHIPS, 1976

Country	Energy/GDP Ratio (tons oil equiv. per US$ million)	Energy/GDP Ratio (Index, Canada = 100)
Canada	1,772	100
United States	1,498	85
Japan	1,280	72
France	978	55
West Germany	1,206	68
Italy	1,244	70
Netherlands	1.663	94
Sweden	1,341	76
United Kingdom	1,510	85

SOURCE: OECD, National Accounts of OECD Countries, Paris, 1976.
OECD, Energy Balances of OECD Countries, Paris, 1976.

households. This implies that higher consumption is rewarded by a lower price which in turn encourages more consumption.

As mentioned above, the energy/output ratio has its shortcomings. The first of the two main ones which we should discuss is that the ratio cannot be used as either an indicator of economic or energy efficiency. A profit seeking entrepreneur will typically achieve economic efficiency by choosing the least costly combination of all needed inputs of production, including land, labour, capital, materials, and energy. Because of this and the already mentioned fact that relative to other inputs, energy is much less significant, it would clearly be improper and inefficient to attempt to minimize only the E/GDP ratio or to take the ratio as an indicator of economic efficiency. Furthermore, since at least to some extent it is always possible to substitute one factor input for another, such that the total cost of production is minimized, production (and consumption) will typically be made more energy intensive in countries with lower energy cost. This is particularly true of Canada where historically lower energy prices provided for an incentive to substitute energy for other inputs (capital, labour, land or time). The resulting differences in the intensity of energy use between countries will not therefore indicate economic efficiency but could help in revealing the potential for energy savings, which in the present context is synonymous to energy conservation.

The E/GDP ratio will as well not be a good measure of energy efficiency because no two countries will engage in the production of output whose structure is exactly the same. Although the value of output in monetary terms may be equal between two countries, different amounts of energy may be required to produce them (e.g., aluminum vs. light manufacturing or fruit growing).

The second important caveat pertaining to the international comparisons of energy use based on the E/GDP ratio is the following. The word 'waste' can be used without ambiguity in the present context only if it implies an extra amount of energy used in one production process (or one country) producing an identical output as in another process (or country), provided that both processes are executed under identical conditions and environments. This requires identical climate, factories, productivity, raw materials, etc., but more importantly identical historical prices paid for not just energy but also for all other inputs - a condition which will simply never hold in an international setting. Differential pricing of input factors between two countries will result in differential use of inputs. The important

consequence of such differences is that nothing can be concluded about the existence of waste of energy or any other input, as long as the producers' profit, not their energy to output ratio is the numeraire guiding their business decisions. Hence nothing can be said without ambiguity about Canada wasting this or that natural resource relative to other countries operating under not dissimilar but in important ways different circumstances.[3] For instance, the fact that an average Canadian uses more gasoline to drive his car a given distance than an average Japanese is not due to some inherent wasteful nature of Canadians but rather has its origin in well-explicable economic circumstances.

Despite these shortcomings, there are at least three ways in which the E/GDP ratio can be very useful. These are:

(i) in revealing that different amounts of energy will be used to produce a given output which in turn can point out sectors worthy of further study to assess the conservation potential;

(ii) in illustrating the effects of different energy prices across countries on their levels of energy utilization; and

(iii) in indicating the rate at which energy is being saved through the examination of changes in the ratio over time.[4]

The next chapter, Chapter 3, will examine some of the sectoral E/GDP ratios of a selected group of countries during one recent year. This will help to show whether and where, relative to other countries, an energy saving potential exists in Canada. Whenever the Canadian E/GDP ratio of a given sector is found greatly in excess of that of some other country, it will be taken as an indication of an energy saving potential in Canada, though not a proof that realizing it will be economical. In Chapter 4, three sectors and their E/GDP ratios will be studied for a period of sixteen years to determine the rates of energy conservation during that time period. The monitoring of the ratios for each country will be particularly important during the most recent period when relative prices of energy have changed from their long-term historical relationships following the events of 1973. It is expected that given the large price increases, some downward adjustments in energy consumption have been made. The relative changes of energy prices for Canada are shown in Table 2.8, where it will be noted that, in real terms, the years 1974-75 were marked by large increases, putting an end to a long preceding period of falling real prices of energy. These relationships can in turn be better shown graphically as in Figure 2.1, where the real energy prices are plotted in an index form with 1962 as the base year. Chapter 5 will present summary and conclusions.

TABLE 2.8

INDICES OF CANADIAN ENERGY PRICES IN REAL TERMS, 1962-1977
(1962 = 100)

Year	Consumer Price Index 1962 = 100 (1)	Average Price Canadian Crude (Wellhead Price) (2)	Landed Price Imported Crude Oil Montreal (3)	Average Wellhead/Plant Gate Price of Natural Gas (4)	Average Revenue /kW.h for all Customers, Canada (5)	Price Imported Bituminous Coal Used in Electricity Generation (6)
1962	100.0	100.0	100.0	100.0	100.0	100.0
1963	101.7	105.8	96.8	107.4	106.0	98.8
1964	103.5	105.3	92.9	110.7	102.0	94.5
1965	106.0	103.1	87.3	106.6	100.0	92.2
1966	110.0	99.5	82.0	107.4	93.0	87.6
1967	113.9	118.3	78.5	106.6	93.0	85.6
1968	118.6	92.4	76.7	102.4	91.0	80.1
1969	123.9	88.3	71.4	97.5	88.0	78.1
1970	128.1	87.0	67.2	97.5	88.0	80.7
1971	131.8	92.4	75.3	93.3	90.0	92.5
1972	138.1	89.2	79.2	94.2	84.0	93.1
1973	148.5	102.2	78.1	96.6	82.0	89.9
1974	164.7	154.4	217.6	137.1	79.0	93.1
1975	182.5	175.4	243.6	252.0	83.0	139.0
1976	196.3	193.3	232.4	365.8	81.6	-
1977	213.1	214.7	250.1	-	-	-

SOURCES: A.P. Ellison, "Past and Future Energy Costs in the Canadian Economy," Table 4.5, p.133; Bank of Canada Review, July 1978; and CPA, Statistical Handbook, 1977.

NOTE: Columns (2), (4), and (5) are average prices rather than marginal prices to which both industry and consumers respond.

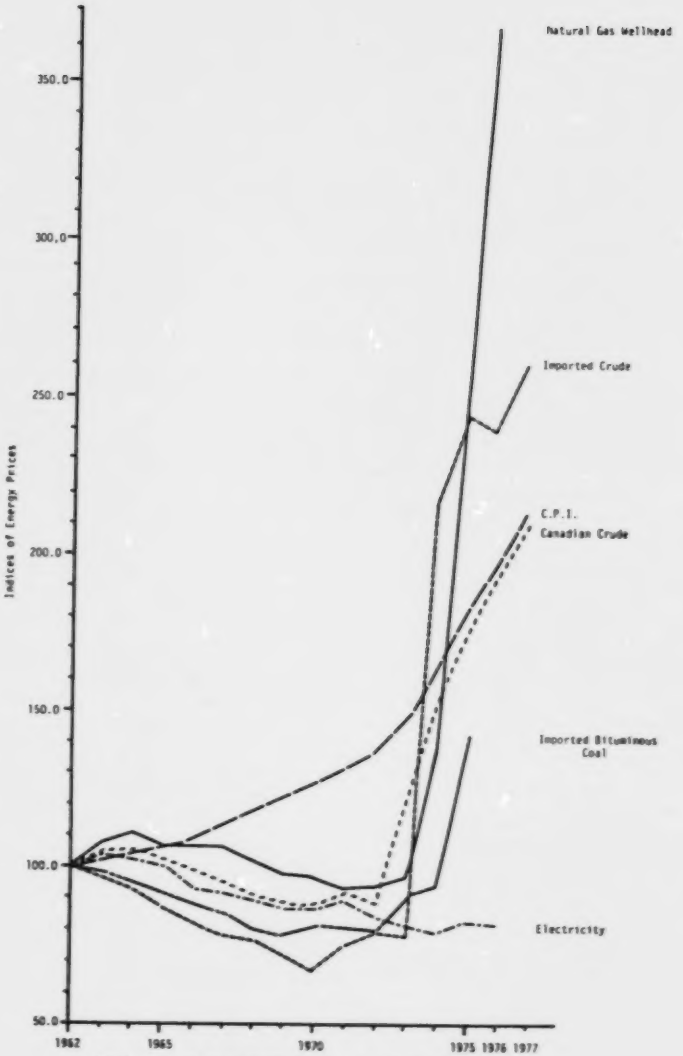

FIGURE 2.1: Indices of Canadian Energy prices in Real Terms, 1962 - 1977.

SOURCES: A.P. Ellison, "Past and Future Energy Costs in the Canadian Economy," Table 4.5, p.133; Bank of Canada Review, July 1978; and CPA, Statistical Handbook, 1977.

Footnotes

[1]Extensive literature exists dealing with the problem of conservation on a much more theoretical level. See for example S. V. Ciriacy-Wantrup, Resource Conservation, 3rd ed. (Berkley: University of California Press, 1968); H. E. Gordon, "Economics and the Conservation Question," The Journal of Law and Economics 1 (October 1958):110-121; H. Hotelling, "The Economics of Exhaustable Resources," Journal of Political Economy 39 (April 1931):137-175; A. D. Scott, Natural Resources: The Economics of Conservation, (Toronto: University of Toronto Press, 1955; reprint ed., Toronto: McClelland and Stewart Ltd., 1973); and R. M. Solow, "The Economics of Resources and the Resources of Economics," American Economic Review 65 (May 1974):1-14.

[2]'Intensities of energy use' simply means the amount of energy used relative to output. A highly intensive use of energy implies a heavy usage relative to output and vice versa.

[3]Note that the definition of 'waste' in the text is not intended for the purpose of policy but mainly to narrow down the meaning of the word in the present context. As such the definition does not aspire to measure waste in some physical units but merely suggests that precisely that would be very difficult, if not impossible. The prime reason for its inclusion in the text is to point out the ambiguity and the fallacy of the opening quotations in Chapter 1 which represent the popular interpretation of the word today.

[4]For a detailed analysis of the E/GDP ratio, its uses and shortcomings see J. Dunkerley, ed., International Comparisons of Energy Consumption (Washington, D.C.: Resources for the Future, 1978) Research Paper R-10, especially pages xiv-xxxiii and 201-214.

CHAPTER 3

INTERNATIONAL PERSPECTIVE ON CANADA'S ENERGY USE

In Table 1.1 at the beginning of this study, Canada was shown to consume energy in excess of all other countries examined when compared on either a per capita or per dollar of GDP basis. It is now instructive to explain, however partially, where the difference lies between Canada and the other countries in energy utilization and to single out the particular sector or sectors of the Canadian economy which contributes most to this difference. In doing so, the E/GDP ratio will be considered first for the economy as a whole and then for each of the following sectors or industries: total industry, iron and steel, chemical and petrochemical, transport, residential, and agricultural. The selection of these sectors is partly dictated by the availability of data but it is also based on the fact that these sectors are among the heaviest users of energy.[1] When taken together they account for some 80 percent of the total final consumption of energy (TFC) in Canada in 1976 but they are responsible for up to 95 percent in the case of Japan. The importance of each of these sectors for all countries expressed as a percentage of TFC can be seen in Table 3.1. Total industry includes manufacturing (which comprises a large number of industries of which two, iron and steel, and chemical and petrochemical industries, are also examined separately), mining, construction, and utilities. The selection of countries used in this inquiry was based on two criteria, the availability of data and the attempt to compare countries characterized by a similar industrial development and standard of living.

Following the brief sectoral exposition of consumption patterns in all of the selected countries in this chapter, the next chapter will look at the levels of energy utilization over time from 1960 to 1976 for the following sectors: total industry, iron and steel, and transport.

TABLE 3.1

PERCENTAGE SHARES OF TOTAL FINAL ENERGY CONSUMPTION (TFC)
BY VARIOUS SECTORS, 1976

	Total Industry	Iron & Steel[a]	Transportation	Agriculture	Residential Sector	Petrochemical & Chemical[a]
Canada	31.0	3.9	28.5	1.2	19.3	4.1[b]
United States	27.8	4.3	33.1	0.22	27.4	4.1
Japan	54.3	19.9	17.6	3.0	20.2	8.6
France	38.4	9.0	21.8	2.1	29.6	3.7
Germany	38.3	11.2	17.9	1.0	35.6	4.4
Italy	46.6	8.1	17.2	1.9	28.7	11.4
Netherlands	38.6	4.6	15.3	0.58	29.1	11.5
Sweden	41.6	6.6	15.3	1.9	35.2	3.4
United Kingdom	35.3	7.9	21.1	1.2	35.1	6.2[b]

SOURCE: OECD, Energy Balances 1974 - 1976, Paris, 1978.

[a]A part of "Total Industry".

[b]"Chemical" industry only.

The Industrial Sector

Figure 1.1 of Chapter 1 showed the total energy consumption per dollar of gross domestic product for the economy as a whole for a group of selected countries in recent years. Figure 1.1 is reproduced here as Figure 3.1. It can be clearly seen that the two North American countries use more of the energy input relative to most others, in some cases substantially more. What sector or sectors are responsible for this overall difference?

Let us first consider total industry in Table 3.2. As mentioned above, total industry includes manufacturing (including iron and steel, and chemical and petrochemical industries which will also be examined separately), mining, construction and utilities. With the exception of the Netherlands and Italy, Canada used more energy than all other countries to produce her industrial output valued in common monetary units. While the industrial sectors of Canada, Italy, Japan, the U.K., and the U.S. consume energy at not dissimilar levels, it is Sweden, and even more so France and West Germany (hereafter Germany), that exhibit a substantially lower use of energy per dollar of industrial output.

Various factors determining the amount of energy used mentioned in the previous chapter will account for this difference. Out of these, two are particularly important for the industrial production. First, because the compostition of the industrial output will not be uniform across the selected countries, the energy/output ratio will be higher for countries whose industrial production or outputs are more energy intensive. Second, industrial production can be expected to be more energy intensive in countries where the energy inputs have traditionally been cheaper as in Canada and the U.S.[2] More energy will then be used relative to other factors of production, labour and capital. A further important aspect of industrial production in a country with relatively cheap energy is the conspicuous absence of utilization of industrial energy by-products, such as waste heat from thermal electricty generating plants. For example in Sweden, a country with a population of 8.2 million people and a similar climate to that of Canada, district heating using waste heat presently provides space heating equivalent to the requirements of a city with a population of 100,000 people.[3] On the other hand, in countries with cheap primary energy, waste heat utilization has not been economically viable and hence most or all of it is discharged into the environment.

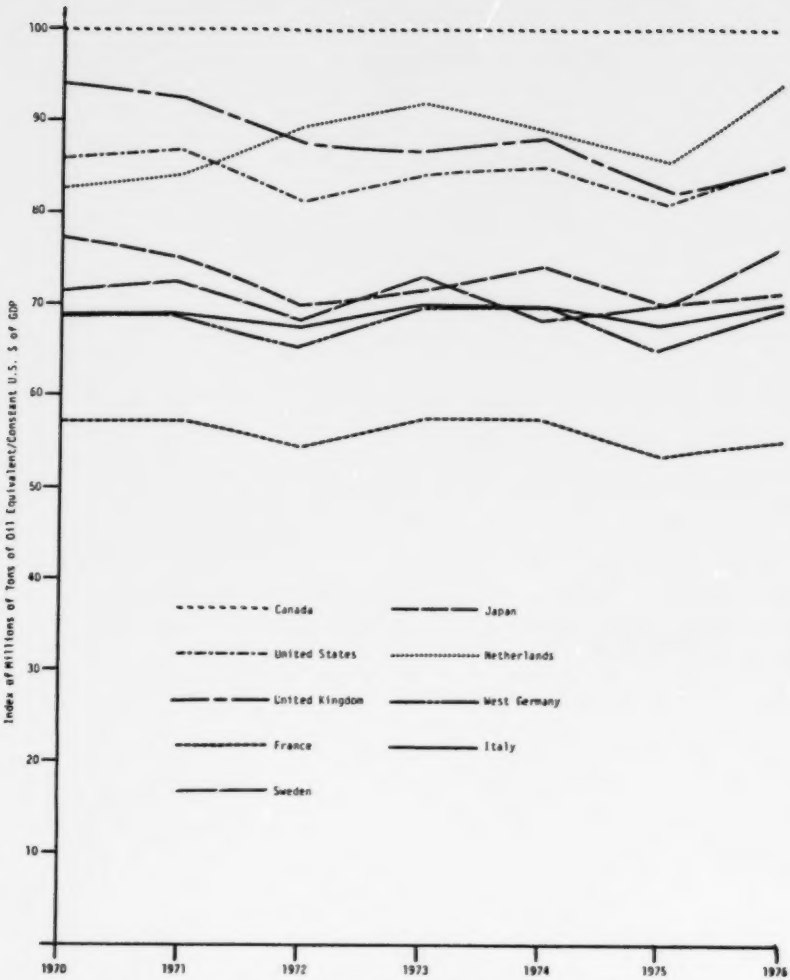

FIGURE 3.1: Index of Energy Consumption per Constant Dollar of Gross Domestic Product, 1970 - 76. (millions of tons of oil equivalent/constant U.S. dollar of GDP, Canada = 100)

SOURCES: National Accounts of OECD Countries, Paris, 1976.
Energy Balances of OECD Countries, Paris, 1976.

TABLE 3.2

E/GDP RATIOS FOR TOTAL INDUSTRY, 1976

	(1) GDP_I [US$ mill.]	(2) E_I [MTOE][b]	(3) (2) ÷ (1) thous. of TOE[c] / mill. of $	(4) Index of (3) Canada = 100
Canada	61,348	41.14	.671	100
United States	564,700	357.91	.634	94
Japan[a]	197,485	131.09	.664	99
France	131,402	52.42	.399	59
Germany	229,313	73.83	.322	48
Italy	73,710	49.76	.675	101
Netherlands[a]	27,523	21.06	.765	114
Sweden	26,506	15.42	.582	87
United Kingdom	80,108	50.90	.635	95

SOURCES: OECD, Energy Balances 1974-1976, Paris, 1978; and
OECD, National Accounts of OECD Countries, Paris, 1976.

[a]Data pertain to 1974.

[b]Millions of tons of oil equivalent.

[c]Tons of oil equivalent.

Industrial output will be more energy intensive when the finished products of one country contain more energy than those of another country. A country engaged heavily in the production of, for example, aluminum, refined petroleum products, steel, or pulp and paper will as a rule display an industrial energy/output ratio much higher than an industry characterized by a strong orientation towards less energy-demanding products, such as processing of food, textiles, light manufacturing, electronics, etc.

Table 3.3 compares Canada with France and Germany, the two countries with significantly lower industrial energy/output ratios than Canada. In the upper panel, selected energy intensive products are compared on a per capita basis. In the lower panel, the same is done for selected industrial products which typically need less energy to produce.[4] It can be seen from the upper panel that Canada produces substantially more of highly energy intensive raw aluminum, petroleum products, wood pulp and newsprint than both France and Germany. In the production of crude steel, pig iron and ferro-alloys (all energy intensive products), Canada produces more than France but slightly less than Germany. Canada trails both of these countries in the output of cement (also an energy intensive product). These findings are of interest especially in connection with Table 3.4 which indicates the amounts of energy used in the production of some of the most energy intensive industrial products in different countries as estimated by the International Energy Agency.[5] In looking across the columns of Table 3.4 it becomes clear that aluminum, pulp and paper, and crude steel appear to be the most energy demanding ouputs. Then, given Canada's relatively high output of aluminum, wood pulp, petroleum products and newsprint (Table 3.3), combined with her generally much higher energy use in the production of these commodities (Table 3.4), it is not surprising that when compared to Germany or France (Table 3.2), Canada was found a heavy user of energy in the industrial sector.[6] On the other hand, both France and Germany are more heavily engaged in the production of some industrial outputs characteristically requiring less energy to produce. The lower panel of Table 3.3 shows just that.

Darmstadter et al.[7] described these two types of greater energy use in production as the 'structure-intensity dichotomy', a problem which will be present in every international comparison. Before any normative conclusions are drawn from international comparisons of energy use it should be realized that the differences in structure and intensity are in themselves largely a result of comparative advantage in natural resources[8] some countries enjoy and also

TABLE 3.3

INDUSTRIAL PRODUCTION LEVELS, 1975

	Aluminum (mill metric tons/cap.)	Crude steel, pig iron and ferro-alloys (metric tons/cap.)	Petroleum Products (metric tons/cap.)	Wood Pulp (tons/cap.)	Newsprint (tons/cap.)	Cement (tons/cap.)
Canada	40.71	1.062	3.62	.274	.323	.452
France	7.28	.758	1.95	.007	.005	.553
Germany	11.17	1.166	1.52	.013	.008	.565

	Butter (tons per '000 cap.)	Cheese (tons per '000 cap.)	Sugar (tons/cap.)	Cotton Yarn (tons per '000 cap.)	Wool Yarn (tons per '000 cap.)	Radio & TV Receivers (per '000 cap.)
Canada	6.09	6.19	.006	3.58[a]	.55[a]	70.10
France	10.56	17.79	.052	5.30	2.55	88.63
Germany	8.59	10.19	.042	3.52	.85	12.81

SOURCE: UN, Statistical Yearbook, 1977, various tables.

[a]Data pertain to 1974

TABLE 3.4

ENERGY USE IN THE PRODUCTION OF SELECTED INDUSTRIAL OUTPUTS[a]
(10^4 kcal/ton)

	Crude Steel		Pulp & Paper		Cement		Petroleum Products		Aluminum	
Canada	555.0	100[b]	673.0	100[b]	95.0	100[b]	179.6	100[b]	N/A	
U.S.A.	543.0	98	579.0	86	161.4	170	89.7	50	946.5	100[c]
Japan	513.3	92	512.2	76	119.6	126	46.0	26	1385.0	146
France	N/A		N/A		N/A		N/A		N/A	
Germany	326.0	59	438.2	65	90.8	96	80.0	45	1481.0-1503.0	156-159
Italy	334.0	60	340.0	51	96.0	101	44.8	25	N/A	
Netherlands	470.0	85	N/A		131.4	138	N/A		1290.0	136
Sweden	397.8	72	489.0	73	139.7	147	49.0	27	1648.2	174
U.K.	478.0	86	627.0	93	138.4	146	73.4	41	2106.6	223

SOURCE: International Energy Agency, Energy Conservation, Paris, 1976, Tables 12-16.

[a]See footnote 5.

[b]Index Canada = 100

[c]Index U.S.A. = 100

of a number of non-economic factors such as climate, geography or density of population. The comparative advantage in natural resources also helps to explain the historical levels of prices paid for energy products and some of the existing traditions in production of particular outputs, as well as provide a basis (in the countries possessing it) for a more energy intensive life style.

Looking back at the industrial sectors of all countries in Table 3.2, a tentative conclusion can be reached that, with the exception of the petroleum products group, pulp and paper and crude steel, where the Canadian use of energy is significantly higher (Table 3.4), it is not the industrial sector which accounts for much of the overall difference in the E/GDP ratio. On the other hand, the relatively higher use of energy in Canada apparent in Table 3.4 clearly indicates a conservation potential whenever the Canadian figure exceeds that of another country by a significant amount, as in the case of Germany.

The existence of an energy conservation potential in the industrial sector has also been acknowledged by spokesmen of this sector of the Canadian economy. During the Second Conference on Industrial Energy Conservation in March, 1976, various task forces organized by Canadian industries expressed their own views on the potential for energy conservation. Among the estimates put forward by the task forces were, for instance, a goal of 9 to 12 percent savings of energy during 1974-1980 per ton of output of the cement industry; up to 12 percent reduction in energy use per ton of product by 1980 by the pulp and paper industry; and the machinery sector, including all types of machinery used in both primary and secondary industries (except manufacturers of electrical and transportation machinery), set for itself a goal of a 15 percent reduction in energy consumption by 1980, and identified energy savings beyond that time of 25-30 percent as possible.[9]

The Iron and Steel Industry

Included in the iron and steel industry which falls within the industrial sector is the production of pig-iron, direct castings, crude steel, both ingots and steel for castings, and ferro-alloys. The relative levels of energy consumption and output for all countries are shown in Table 3.5 in the first two columns. Rather than measuring the output in this sector in monetary terms, the availability of data has made it possible to use physical units. This eliminates the possible bias introduced into the analysis when the going exchange rate in any

TABLE 3.5

IRON AND STEEL SECTOR, 1975

	(1) Energy Used [MTOE]	(2) Output[a] [thous. of metric tons]	(3) (1) ÷ (2) [TOE/1,000 metric tons]	(4) Index of (3) Can. = 100	(5) Energy Used as % of TFC[b]	(6) Iron & Steel Production per Capita [tons/cap.]	(7) Index of (6) Can. = 100	(8) Crude Steel as % of Output of (2)
Canada	5.06	22,897	221.0	100	3.9	1.06	100	56.9
United States	56.47	180,332	313.1	142	4.3	0.89	84	58.7
Japan	47.86	191,329	250.1	113	19.9	1.71	161	53.5
France	12.18	39,845	305.7	138	9.0	0.76	72	54.0
Germany	22.45	70,744	317.3	144	11.2	1.17	110	57.1
Italy	8.37	33,159	252.4	114	8.1	0.62	58	65.0
Netherlands	2.34	9,121	256.6	116	4.6	0.70	66	52.9
Sweden	2.73	9,121	299.3	135	6.6	1.11	105	61.5
United Kingdom	10.58	32,536	325.2	147	7.9	0.59	56	62.1

SOURCES: OECD, Energy Balances, 1974-1976, Paris, 1978; and
UN, Statistical Yearbook, 1976, New York, 1977, Tables 125 and 126.

[a]Included are total production of crude steel (both ingots and steel for castings obtained from pig-iron or scrap), pig-iron, direct castings and ferro-alloys. Excluded is the output of wrought (puddled) iron.

[b]Total final consumption of energy.

given year is used to translate all currencies into a common one to evaluate the output in all countries. The result is a more accurate energy/output ratio for all economies compared. In column 3 of Table 3.5 is the energy/output ratio which is for convenience expressed in an index form in column 4. Surprisingly, Canada shows the lowest energy consumption per unit of output in the production of iron and steel. It will be recalled that in Table 3.4, in the production of crude steel only, Canada was shown to use more energy to produce a ton of steel than any other country examined. Since the output of this sector includes more than crude steel, it must be that in Canada, less energy is used for the production of pig-iron and ferro-alloys than in most other countries. The percentage share of crude steel relative to all other components of output of this sector in each country is listed in column 8 of Table 3.5. The table shows that the highest consumers of energy relative to output are the U.K., Germany and the U.S. with Japan, Italy and the Netherlands using more energy than Canada by a little over 10 percent.

Although the output of this sector may be considered as being more homogeneous across different countries than for example the output of 'total industry', the problem of structural differences is nevertheless present. It takes the form of varying requirements of energy in steel production when either iron ore or pig-iron and scrap are used as inputs in the production of steel. It will also be of great importance whether a high or low quality iron ore is used, for the former will require less blast furnace energy than the latter. Thus, since it is known that Sweden and Canada produce a high quality iron ore, these two countries will as a rule need less energy to produce a ton of steel than for example France where the iron ore used is of a lower quality.

The variations in energy use in the production of iron and steel are also a result of different technologies employed in this sector by each country. Darmstadter et al. report that the amount of energy needed in making steel will vary importantly with the type of blast furnace used.[10] They estimated that at this stage the production process accounts for some 15 or 20 percent of the total energy used in this sector and hence a multiple energy savings will become possible for those countries employing a less energy intensive technology. Of the three most widely used methods--the open hearth, oxygen and the electric arc--the first was estimated as being over twice as energy intensive as the latter two.[11] Darmstadter et al. further observe that it is the U.S., but even more so Canada and the U.K., where the open hearth method is widely used. On the other hand, Japan and the Netherlands employ this method of steelmaking to a much

lesser extent. It could be interesting to speculate why it is that some countries use technologies which are more energy intensive. One answer might be that the use of such technologies has to do with historically lower prices of energy (as in the U.S. and Canada) or lower prices of other factors of production, and perhaps also with the age of the plants. As the older method of steelmaking--the open hearth --uses more energy to produce a ton of steel, a country with a large old capacity, such as the U.K., will generally use more energy to produce a given amount of output. Since in Canada the open hearth method of steelmaking is widely used, and the one reason for this may be the historically lower price of energy, the finding that the Canadian energy/output ratio in this sector was the lowest of all countries appears inconsistent.[12] Since no additional data were found which would repudiate the figures in Table 3.5 (columns 1 and 2), the results obtained here must be interpreted with this apparent inconsistency in mind.

Additional information is provided in columns 6 and 7 of Table 3.5. It gives an indication of the relative sizes of this sector in these countries. An interesting comparison is offered between columns 4 and 5 of Table 3.5 where column 5 shows the energy used in this sector as a percentage of TFC and column 4 the index of the energy per output ratio in each country. The striking comparison is, for instance, between Canada and Japan. While the energy/output ratio is only 13 percent higher for the Japanese iron and steel sector, the importance of this industry for the Japanese economy is over five times greater than in the case of Canada. This means that the 13 percent higher energy use by this sector in Japan becomes in fact very significant in accounting for the overall difference in energy use between the two countries.

The Chemical and Petrochemical Industries

These two industries fall within 'total industry' and include the manufacture of chemicals and chemical petroleum, coal, rubber and plastic products. The importance of these products for energy consumption in each country can be seen in Table 3.6. Column 4 of this table displays the index of the energy/output ratio and it can be seen that Germany, France, the U.S. and Sweden consume significantly less energy to produce a given value of output than Canada. The lower panel of Table 3.6 provides an indication of per capita output levels of some of the main products in each country. Since all the specific energy requirements in the production of these selected outputs are not known, it is impossible to formulate a weighting scheme which would help to

TABLE 3.6
CHEMICAL AND PETROCHEMICAL SECTOR, 1976

	(1) Energy Used [MTOE]	(2) GDP Generated [mill. $US]	(3) Energy per GDP (1) ÷ (2) [TTOE ÷ mill $]	(4) Index of (3) Can. = 100	(5) Energy Used as % of TFC
Canada	5.49	2,772	1.98	100	4.1[d]
United States	70.93	53,500	1.33	67	4.1
Japan	38.36	18,219	2.11	107	8.6
France	13.66	16,408	0.83	42	3.7
Germany[a]	20.64	25,412	0.81	41	4.4
Italy	19.26	6,777	2.84	143	11.4
Netherlands	12.41	6,582	1.89	95	11.5
Sweden	2.24	1,691	1.32	67	3.4
United Kingdom	8.99	-	-	-	6.2[d]

	Production Levels[a]					
	Nat. Gas Liquids [tons/1,000 cap.]	Gasoline [metric tons /cap.]	Fuel & Lub. Oils [metric tons /cap.]	Plastics & Resins [metric tons/ 1,000 pop.]	Basic Organic Chemicals[c] [metric tons/ 1,000 pop.]	Rubber [metric tons/ 1,000 pop.]
Canada	487.3	1.209	1.901	19.9[b]	48.8[b]	8.20
United States	263.6	1.385	1.034	45.6	123.0	9.93
Japan	0.21	0.191	1.222	41.9	90.8	7.47
France	15.53	0.315	1.367	29.7	13.1	7.10
Germany	0.13	0.280	1.041	44.6	94.8	4.77
Italy	0.78	0.262	1.236	27.0	64.4	3.72
Netherlands	11.8	0.504	2.788	4.0	198.9[b]	16.55
Sweden	-	0.186	1.096	68.9[b]	5.6[b]	1.01[b]
United Kingdom	6.14	0.251	1.030	25.5	41.3	5.14

SOURCES: OECD, Energy Balance, 1974-1976, Paris, 1978; OECD, National Accounts, vol. 2, Paris, 1976, and UN, Statistical Yearbook 1976, New York, 1977.

[a]Pertains to 1975 output.

[b]Figure pertains to 1974.

[c]Not including ethyl alcohol.

[d]Chemical industry only.

sort out the apparent differences in the output structure. Nevertheless, looking at Table 3.6, it is possible to conclude that, for instance, Germany, France, and Sweden produce less (sometimes much less) on a per capita basis of majority of the listed products, notably gasoline whose production is highly energy intensive. On the other hand, this does not hold in the case of the U.S. and to some extent also of the Netherlands. With the exception of natural gas liquids and to a much less extent in the case of fuel oils, the U.S. output is higher for all other products, including gasoline. In the case of the Netherlands, it is difficult to pass a firm judgement in the absence of specific energy requirements in the production of the selected group of outputs. Relative to Canada, the Netherlands produces on the one hand a much lower output of natural gas liquids, plastics and gasoline, but on the other, it shows a higher output of fuel oils, basic organic chemicals and rubber. Given that the difference between the Netherlands and Canada in the energy/output ratio is only about 5 percent, the question of whether there exists a conservation potential in this sector in Canada relative to the Netherlands is indeterminate on the basis of the present data. A different situtation arises when Canada is compared with the U.S. Quite clearly structural differences will not account for a one-third lower energy/output ratio in the U.S. Of this one-third less intensive energy usage in the U.S., a part could be explained by a lower per capita output of natural gas liquids. Given the higher output per capita in the U.S. of all other outputs considered here, some of the difference in the energy/output ratio in this industry (33 percent) will likely be due to a lower use of energy per output in the U.S. and hence suggests an energy saving potential for Canada. The aforementioned conference on industrial energy conservation came up with a similar conclusion. The chemical industry task force put forward an overall target for the chemical sector to reduce the consumption of energy per unit of production by 17 percent by 1980 using 1972 as the base year for comparison. By way of example, this is roughly equivalent to saving enough energy to heat all the homes in the Metropolitan area of Toronto for one year.[13]

The Transport Industry

Several recent studies indicated that the transport sectors of both the U.S. and Canada are characterized by a higher usage of energy than their counterparts in Japan and Western Europe. The present study's results support this conclusion and attempts will be made to show exactly where in the transport sector it is that Canada appears to use energy more intensively than others.

Table 3.7 reveals that large differences exist between Canada, the U.S., and the other countries in the ratio of energy consumption per dollar of gross domestic product generated within the transport sector.[14] These differences are shown to amount to more than 100 percent.

Although limited, available data permit a more detailed analysis of three subsectors within the transport sector. These are air, rail and car travel. With output expressed in physical rather than in monetary terms (the energy consumed is related to freight or passenger-kilometres per year), the necessity to standardize output in one monetary unit is again absent and hence greater confidence can be placed on the resultant figures. Table 3.8 shows the percentage distribution of energy consumption among the different modes of transport for all countries and Tables 3.9, 3.10 and 3.11 show the energy per passenger and cargo distance travelled respectively by air, rail and car.[15] From Table 3.8 it is apparent that within this sector, road travel accounts for a high and more or less uniform (between 71 and 87 percent) percentage of transport energy consumption in all the countries considered. Slightly more variation is encountered in rail travel and even more in air transportation. Thus, if large differences exist among countries in road travel, they will be very important in explaining the differences in this sector and in overall energy use.

Difficulties, however, are encountered particularly in the air travel subsector since it appears that data on international air transport are complied in a way inconsistent with the present analysis. For example, if a Canadian plane refuels at London's Heathrow airport, the fuel thus used (sold) will show in the U.K.'s fuel consumption but the air miles travelled by the aircraft will be added by Canada. Keeping this difficulty in mind, the main purpose of the brief exposition of the air transport subsector will be to indicate the intensity of air travel in all countries examined, rather than to draw specific conclusions from the ratio of energy to travelled air-kilometres.

Table 3.9 depicts the air transport subsector. The first three columns show, respectively, the number of passenger and freight metric ton-kilometres travelled,[16] energy used, and the ratio of energy to distance travelled; column 4 shows the index of this ratio. More significant are the last two columns, which give some indication of the intensity of both passenger and freight air travel. It is clear that, particularly in terms of passenger air travel, Canada and the U.S. use this mode of transport much more extensively than all other countries examined.

TABLE 3.7
TRANSPORT SECTOR, 1976

	(1) GDP Generated [mill. $US]	(2) Energy Used [TTOE]	(3) E ÷ GDP [(2) ÷ (1)]	(4) Index of (3) Can. = 100	(5) Energy Used as % of TFC
Canada	14,199	37,800	2.45	100	28.5
United States	107,900	425,820	3.95	161	33.1
Japan[a]	30,366	39,830	1.31	41	17.6
France	18,858	29,830	1.58	64	21.8
Germany	26,100	34,460	1.32	54	17.9
Italy	9,468	18,340	1.94	79	17.2
Netherlands[a]	4,942	6,980	1.41	44	15.3
Sweden	3,563[b]	5,650	1.59	65	15.3
United Kingdom	18,519	30,460	1.64	67	21.1

SOURCES: OECD, Energy Balances 1974-1976, Paris, 1978; and
OECD, National Accounts of OECD Countries, Paris, 1976.

[a]Data pertain to 1974.

[b]Government contribution to GDP for 1976 has been estimated on the basis of its growth in previous three years.

TABLE 3.8

TRANSPORT SECTOR, 1975
Percentage Distribution of Energy Consumption among Different Modes of Travel

	(1) Road	(2) Air	(3) Rail	(4) Energy used in Transport as % of TFC
Canada	81	10	6	28.5
United States	84	13	3	33.1
Japan	73	4	5	17.6
France	87	7	5	21.8
Germany	84	7	5	17.9
Italy	86	7	3	17.2
Netherlands	71	12	7	15.3
Sweden	83	12	6	15.3
United Kingdom	78	14	4	21.1

SOURCE: OECD, Energy Balances 1974 - 1976, Paris, 1978.

NOTE: Numbers in columns 1, 2 and 3 may not add up to 100 due to rounding or to absence of energy used in navigation.

TABLE 3.9

AIR TRANSPORT, 1975

	(1) Pass. & Freight ton-km [mill.]	(2) Energy Used [TOE]	(3) Energy ÷ Pass. & Freight ton-km	(4) Index of (3) Can. = 100	(5) Pass.-km /cap. [mill./mill.]	(6) Freight ton-km /cap. [mill./mill.]
Canada	25,533	3,530,000	138.3	100	1,159.1	24.8
United States	269,014	51,520,000	191.5	138	1,289.2	34.4
Japan	30,911	1,840,000	59.5	43	268.5	7.6
France	24,272	2,000,000	82.4	60	443.0	18.9
Germany	14,555	2,350,000	161.5	117	224.8	15.2
Italy	11,196	1,350,000	120.6	87	200.9	7.4
Netherlands	10,910	890,000	81.4	59	791.3	45.0
Sweden	3,764	540,000	143.5	104	442.2	16.4
United Kingdom	30,990	4,130,000	133.3	96	543.9	14.4

SOURCES: OECD, Energy Balances 1974-1976, Paris, 1978; and UN, Statistical Yearbook, 1977, Table 162.

TABLE 3.10

RAIL TRANSPORT, 1975

	(1) Pass. & Net ton-km [mill.]	(2) Energy Used [TOE]	(3) Energy ÷ Pass. Net ton-km	(4) Index of (3) Can. = 100	(5) Pass.-km/cap. [thous. km/ thous. pop.]	(6) Net ton-km/cap. [mill. km/ mill. pop.]
Canada	200,146	2,290,000	11.4	100	135.8	9,144
United States	1,117,585	13,460,000	12.0	105	77.3	5,422
Japan	370,585	1,940,000	5.2	46	2,887.4	423
France	115,013	1,270,000	11.04	97	970.2	1,219
Germany	92,819	1,690,000	18.2	160	622.0	908
Italy	50,574	550,000	10.9	96	670.4	271
Netherlands	11,222	130,000	11.6	102	651.6	209
Sweden	21,917	270,000	12.3	108	714.0	1,956
United Kingdom	59,053	1,240,000	21.0	184	641.0	423

SOURCES: OECD, Energy Balances 1974-1976, Paris, 1978; and
UN, Statistical Yearbook, 1977, Table 155.

TABLE 3.11

CAR TRANSPORT, 1974

	(1) No. of Pass. Cars	(2) Est. Car Use [km/yr.]	(3) No. of Car-km/yr. [mill.]	(4) No. of Cars /10 popul.	(5) Energy Used [MTOE]	(6) E ÷ Car-km/yr. [MTOE ÷ car-km /yr. x 10^{-9}]	(7) Index of (6) Can. = 100
Canada	8,472,000	16,000[a]	135,550	3.93	28.35	.2091	100
U.S.A.	104,270,000	16,000[a]	1,668,300	5.13	335.23	.2009	96
Denmark	1,261,000	16,500[b]	20,807	2.55	1.97	.0947	45
France	15,000,000	11,500[c]	172,500	2.86	23.43	.1358	65
Germany	16,879,000	14,200[c]	239,680	2.78	26.18	.0192	52
Italy	14,295,000	16,000[b]	228,720	2.66	16.35	.0715	34
Netherlands	3,153,000	16,400[b]	51,709	2.47	4.99	.0965	46
Belguim	2,502,200	10,500[c]	26,273	2.59	3.79	.1443	69
U.K.	13,821,000	14,200[c]	196,260	2.49	23.25	.1185	57

SOURCES: (i) AMA (N.D. Lee & Assoc.), estimated that the average Canadian motorist travelled 15,800 km/yr. (1977); the figure for the U.S. was 15,414 km/yr. (1975), personal communication;
(ii) OECD, Energy Balances, 1974-1976, Paris, 1978;
(iii) OECD, The Future of European Passenger Transport, Appendices, Paris, 1977, Table A26.1 and pp. 247-250;
(iv) UN, Statistical Yearbook, 1976, New York, 1977.

[a]An estimate based on OECD (iii) and AMA (i).

[b]1972 estimate by OECD (iii)

[c]1973 estimate by OECD (iii)

Table 3.10 shows the consumption of energy per passenger freight kilometres travelled on rail.[17] From Table 3.8 it is clear that rail transport accounts for only a very small proportion of the total energy consumed in the transport sector ranging from 2 percent for the Netherlands to 6 percent for Canada and Sweden. Table 3.10 shows the rail transport in more detail. It can be seen from the per capita annual kilometres of both passengers and tons of cargo, that the rail transport is with the exception of Italy and the Netherlands, much more significant than air transport in all the European countries and much less significant in Canada and the U.S. It is interesting to notice the striking differences in the usage of this mode of travel by passengers across these countries. For example, the average Japanese travels by rail annually a distance which is about 21 times that travelled by the average Canadian; the average Frenchman travels about seven times more, the average Swede about five times more, etc. In freight movement by rail, Canada leads the way in ton-kilometres per year, with about 43 times more than the Netherlands, 33 times more than Italy, 21 times more than Japan, but only about 1.7 times more than the U.S. It seems that the greater geographical distances in North America (and particularly the distance between producing and consuming areas) are crucial in rail freight transport. Nevertheless, from Table 3.8 it is clear that rail transport accounts for only a modest percentage of the total energy consumption in the transport sector.

In order that the differences in rail transport become important in explaining the total variations in this sector, a characteristic pattern of differences would have to exist between the countries that are heavy and light users of energy here. Instead, it was observed that Canada uses 6 percent of its transport energy for rail transportation, the highest proportion for the countries examined (together with Sweden). The rail transportation takes predominantly the form of moving cargo, with Canada displaying the highest number of ton-kilometres per capita. In fact, with the exception of Japan, Canada's ratio of energy used in the rail transport per passenger and freight-kilometres when taken together, is one of the lowest among the countries compared.

In both the air and the rail transport subsectors some of the European countries displayed a higher value for the ratio of energy use to kilometres travelled when compared to Canada. This is not the case in the passenger car subsector. As Table 3.11 clearly shows, the two North American countries use substantially more energy to generate a given number of car-kilometres per year than any of the other countries. In fact three countries (Italy, Denmark and the Netherlands)

consume less than a half of what Canadian car motorists use to drive one kilometre; two countries (Germany and the U.K.) need slightly more than one half; and two others (France and Belgium) fall between 60 and 70 percent of the Canadian level of energy use per passenger-kilometre travelled. The intensity of energy consumption within this subsector in the U.S. is only some four percent below that of Canada. For illustration, column 6 (energy consumed per number of car kilometers travelled during one year) from Table 3.11 is shown as a diagram in Figure 3.2 with the numbers in brackets indicating the percentage of total energy consumption in the transport sector devoted to 'road' travel.[18]

Given the consistency of the differences in Figure 3.1 between Canada and the U.S. on the one hand and the rest of the countries on the other, and the high percentage for which 'road' travel accounts in the transport sector, it can be concluded that it is passenger car transport where much of the overall difference in energy use lies. Therefore, an energy saving potential should exist in Canada (and in the U.S.) in this sector. In other words, it is the transport sector and in particular passenger car travel where Canadians use much more energy when compared with motorists in the other countries. The reasons for this difference are manifold but they originate largely with the historically lower energy prices in North America, encouraging larger and heavier cars with bigger engines. Many larger cars in North America are also equipped with energy-consuming accessories, such as air conditioning. Combined with the early introduction of the assembly-line type of automobile production which made for a lower and an accessible price for cars and higher per capita incomes in Canada (and the U.S.) relative to Japan and Western Europe during the last four decades or so, we observe an historically much higher per capita car ownership in Canada and the U.S. than elsewhere. The economies of large scale car production and the resulting spin-offs in the car servicing industries made it also possible for the overall cost of operating a car to be much lower in the two North American countries than in Japan or in Europe.[19]

It is usually assumed that due to the greater geographical distances in North America, in Canada we drive more kilometres than do motorists in Japan or in Europe. From the crude estimates in Table 3.11, column 2, it appears that on the average, drivers in Denmark and the Netherlands drive each of their cars slightly more in a year and that in Italy the average yearly car-kilometreage is the same as in Canada and the U.S. The difference therefore lies in the per capita car ownership (see column 4) rather than in the average utilization of

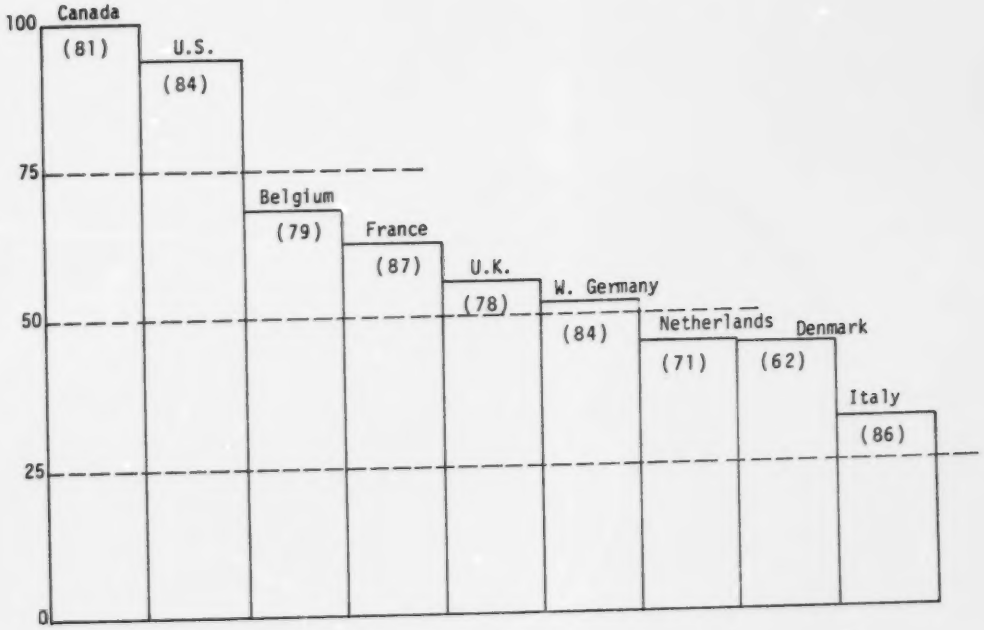

FIGURE 3.2: Passenger Car Transport, 1974.
(Index of E-consumption per number of car-km travelled, Canada = 100)

each vehicle. In other words, the intensity of car utilization is quite comparable between the two North American countries and many others examined here but in both the U.S. and Canada, the total use of cars is more extensive.

The use of a car is of course closely related to the price of fuel which accounts for the bulk of the cost of operating a motor vehicle. The existing differentials in the price of gasoline between countries can point to reasons why the North American motorists use more fuel per given distance travelled. In 1976 for example, the Japanese price of gasoline was 2.1 times the Canadian price and if an average is calculated for all European countries examined here, that price is some 2.2 times the Canadian price and 2.4 times the price paid by motorists in the U.S. Many of the European countries have also accelerated their gasoline prices more rapidly in recent times than has been the case in Canada. Thus, for instance, the present (Summer, 1979) price of a gallon of gasoline in Germany, France or the U.K. is around $CDN 3.00. On the other hand, the Canadian real price of gasoline has actually declined during the last four years. In the time period from March 25, 1975 to March 1st, 1979, the price of regular gasoline rose by 46.8 percent while wages and salaries rose by 53.9 percent.[20] It is not surprising then that the Canadian sales of gasoline have recently been rising steadily: by 6.9 percent in 1977, by 4 percent in 1978 and by 4 percent during the first quarter of 1979.[21]

These are the main economic reasons for greater energy consumption in car transport in Canada. Besides these, others exist which are equally important. In Canada, for instance, a large number of the yearly car-kilometres will be travelled in sub-freezing temperatures when reduced engine efficiency results in still greater fuel consumption per distance travelled. Except for Sweden, no other country compared here faces a similar environment. In the final analysis it would also matter what portion of the overall car-kilometres travelled was highway as compared with intra city travel and whether the travelling terrain was predominantly mountainous or flat. Since no statistics allowing such disaggregation exist, these differences can only remain acknowledged. What is important is that the passenger car subsector clearly presents a potential for energy savings in Canada relative to Japan and to the selected European countries, and that this sector will play a significant role in explaining the differences in the overall E/GDP ratio.

The Residential Sector

Within the residential or the household sector falls the energy used for space conditioning (heating and cooling), lighting and all the energy needed to power a large variety of home electric appliances. Since it is not possible to identify an output of this sector, consumed energy per dwelling will be used to indicate the intensity of energy utilization in each country. The residential sector is described in Table 3.12.

In this table, the first column shows the absolute amount of energy used and the second translates this amount into a percentage of total energy consumption for each country. It is interesting to see that Canada devotes the smallest proportion of the total energy consumed to this sector. With the exception of Japan, all other countries consume much more. Germany, Sweden and the U.K., for instance, use up to 35 percent of their energy within the household sector. Equally interesting is the information in column 3. Surprisingly, the number of dwellings per thousand of population in Canada is the third lowest with the second lowest (the Netherlands) being almost the same as Canada. Column 5 indicates one important characteristic of the housing stock, the index of central heating utilization in the residential sectors of all countries. The variation here will certainly reflect some of the geographical differences in climate and therefore the lack of central heating (e.g. Italy, France), but perhaps also the age of the housing stock and the fact that the installation of central heating on a wide scale has been only a relatively recent phenomenon.

In order to account for the large and important differences in climate, the concept of degree-days will be used.[22] This permits a more meaningful comparison since it implies that for heating purposes only (i.e., air conditioning is neglected), seasonal differences in temperatures between countries will be eliminated. The typical number of degree days[23] for each country is listed in column 6 of Table 3.12. This in turn is used to calculate the values in columns 7 and 8 which show the energy used in this sector on a per capita and per dwelling basis, adjusted for the climatic differences. The last column, column 9, shows an index of the adjusted energy consumption per dwelling in one year. Some interesting differences exist here. First of all, one notes the strikingly high level of the U.S. and, relative to Canada, low levels of energy use in the case of France and Japan. The U.S. figure is relatively much higher because it includes the energy used in air conditioning, which in the case of the U.S. may

TABLE 3.12
RESIDENTIAL SECTOR

	(1) Energy Used (1975) [MTOE]	(2) Energy Used as % of TFC	(3) No. of Dwellings /1000 Cap.	(year)	(4) Index of (3) Can. = 100
Canada	24.80	19.3	290	1972	100
United States	303.56	27.4	338	1970	117
Japan	48.20	20.2	229	1972	79
France	39.41	29.6	401	1975	138
Germany	63.80	35.6	377	1972	130
Italy	28.91	28.7	324	1972	112
Netherlands	14.55	29.1	286	1971	99
Sweden	11.68	35.2	388	1972	134
United Kingdom	50.26	35.1	345	1972	119

	(5) Index of Central Heating Avail. Can. = 100	(6) Degree Days (at 18°C threshold)	(7) Energy Used With Correction for Climate [TTOE ÷ mill.pop.]	(8) Energy Used/Dwelling in 1 yr., Corrected for Climate [TOE/dwelling]	(9) Index of (8) Can. = 100
Canada	100	3,700	1,150	3.96	100
United States	111	2,030	2,718	8.04	203
Japan	N/A	2,000	797	3.48	88
France	39	2,200	1,260	3.14	79
Germany	56	2,600	1,494	3.96	100
Italy	29	1,700	1,173	3.61	91
Netherlands	36	2,725	1,517	5.31	134
Sweden	100	3,800	1,380	3.56	90
United Kingdom	33	2,200	1,521	4.41	111

SOURCES: OECD, Energy Balances 1974-1976, Paris 1978; J. Darmstadter et al., Tables 4-3, 4-5 and 4-7; and UN, Statistical Yearbook 1976, New York, 1977.

cause a large upward bias. Darmstadter et al. have explained the high U.S. consumption of energy by the relatively larger size of the U.S. (predominantly single family) dwellings, poorer house insulation and the large amounts of energy used for cooling of residential space.[24] They also quote findings of other studies[25] and conclude that the standards of house insulation relative to all other countries is generally higher in Sweden and Canada. This is seen as owing to the prolonged winter conditions which provide the needed economic incentive to insulate in these two countries. Yet, when corrected for the differences in climate, the data in Table 3.12 show that, relative to Canada, no less than four countries, France, Japan, Sweden and Italy need less energy by at least 9 or 10 percent and, in the case of France, by as much as 21 percent. This would suggest that an energy saving potential exists in Canada and that the variations encountered here will be significant in explaining the high overall Canadian E/GDP ratio.

The Agricultural Sector

The agricultural sector has also been examined but the analysis turned out largely inconclusive due to a lack of more disaggregated data. The two things that the available data in Table 3.13 do reveal, however, are the substatial differences in the energy/output ratios between the selected countries, and the relatively insignificant share of this sector in energy consumption in each country.

Summary

The objective of this chapter has been to suggest where the difference lies between Canada and other selected countries in their ways of utilizing energy. A sectoral analysis has been employed to show which sector (or sectors) of the Canadian economy contributed most to such a difference during one recent year. Using the energy/output ratio as an indicator of the intensity of energy usage, the following sectors or industries have been examined in Canada and in other countries: total industry, iron and steel, chemical and petrochemical, transport, residential and agriculture. It was then postulated that when a Canadian energy/output ratio of a given sector is found substantially in excess of that of another country, this could be taken as an indication of an energy saving potential in Canada.

The analysis revealed that as far as the industrial sector (including manufacturing, mining, construction and utilities) is

TABLE 3.13

AGRICULTURAL SECTOR, 1976

	(1) Energy Used/yr.[a] [MTOE]	(2) GDP/yr. [mill. $US]	(3) E ÷ GDP [TTOE ÷ bill. $]	(4) Index of (3) Can. = 100	(5) Energy Used as % of TFC
Canada	1.57	7,192.7	218.3	100	1.2
United States	2.86	49,400.0	57.9	27	0.22
Japan	7.27	31,913.7[b]	227.8	104	3.0
France	2.89	16,550.2	174.6	80	2.1
Germany	1.89	12,716.4	148.6	68	1.0
Italy	2.06	13,559.1	151.9	70	1.9
Netherlands[c]	0.32	3,086.6	103.7	48	0.65
Sweden	0.69	3,297.8	209.2	96	1.9
United Kingdom	1.68	5,594.3	300.3	138	1.2

SOURCES: OECD, Energy Balances 1974-1976, Paris, 1978; and
OECD, National Accounts, Paris, 1976, vol. IV.

[a] Includes agriculture, hunting, forestry and fishing.

[b] The value of GDP in agriculture for 1976 has been estimated on the basis of the growth in this statistic during the preceding four years.

[c] Pertains to 1974.

concerned, the differences between Canada and other countries in the industrial energy/output ratio would not account for much of the difference in the overall E/GDP ratio. Some Canadian industries, however, --the petroleum products group, pulp and paper and crude steel --were found to use significantly more energy per unit of output and hence possible energy savings in this country were suggested. Further potential for reducing the Canadian industrial energy/output ratio was revealed by the analysis of the chemical and petrochemical industries. It was also shown that within the iron and steel sector, the energy/output ratio in Canada was the lowest of all countries compared. Hence it could be expected that the Canadian production of pig-iron and ferro-alloys is in turn less energy intensive than in most countries examined. The existence of a potential for energy saving within the industrial sector was also suggested by various task forces organized by Canadian industries. They set for themselves specific targets ranging from 9 to 30 percent reductions in the use of energy per unit of output in the production of cement, pulp and paper, chemicals and within the machinery manufacturing industry.

The analysis of the transport sector showed that this is the sector where most of the difference in energy utilization between Canada and other countries originates. After examining three modes of transport (air, rail and passenger car), it became clear that the use of energy relative to the distance travelled by passenger cars is higher in Canada than in any of the countries examined; sometimes more than 100 percent higher. It was also shown that no price incentive existed which would tend to reduce the Canadian energy-output ratio in this sector. Thus in passenger car travel, evident energy saving potential exists in Canada which if realized, would help to decrease the difference between Canada and other countries in the overall E/GDP ratio.

Also within the residential sector, Canada was found to consume more energy relative to other countries. After allowing for the differences in climate, at least four countries (France, Japan, Sweden and Italy) use between 9 and 21 percent less energy per dwelling than Canada. Hence also in this sector, an energy saving potential exists in this country.

Owing to a lack of data, the examination of the agricultural sector was inconclusive. It only revealed that although large differences exist in the energy/output ratio between countries, the use of energy as a percentage of TFC in this sector is much less significant than in other sectors examined in this chapter.

Footnotes

[1]One of the most difficult obstacles for any research involving international comparisons is the collection of comparable data. This study is for the most part based on data made available by all member countries through the Organisation for Economic Cooperation and Development (OECD) in Paris. Though industrial specifications or the methods of data collection may sometimes vary between countries, rendering international comparison less effective, the OECD data seem nevertheless the best available for the present purpose.

[2]See Tables 2.1 to 2.5.

[3]A. Doernberg, Comparative Analysis of Energy Use in Sweden and the United States, (Upton, New York: Brookhaven National Laboratory, 1975), p. 13.

[4]There, of course, exist other commodities which typically require either large or small amounts of energy to produce. The present selection has been based on data availability and the energy requirements of production.

[5]"The figures presented here [in Table 3.4] may not be directly comparable because of coverage of statistics (for example, some figures only include purchased energy) and differing conversion factors, the degree of import/export dependence on energy intensive intermediary products such as pulp in the pulp and paper industry, and the non-economic factors such as climatic conditions." (International Energy Agency, Energy Conservation, (Paris: Organisation for Economic Cooperation and Development, 1976), p. 18. For these reasons, the data assembled in Table 3.4 are intended for only approximate comparisons.

[6]Note that for instance in crude steel, the Canadian use of energy is apparently the highest among all the countries compared in Table 3.4. This is in sharp contrast to the results obtained below where the iron and steel sector is a subject of more detailed analysis. One possible reason for this important discrepancy may be that in Table 3.4 the figures relate to the production of crude steel only whereas below, the whole iron and steel sector (including crude steel, both ingots and steel for castings, whether obtained from pig-iron or scrap, pig-iron, direct castings and ferro-alloys) is being considered. See also Table 3.5 below.

[7]Darmstadter, Dunkerley, and Alterman, p. 10ff.

[8]Ibid., Chapter 2.

[9]See Canada, Department of Industry, Trade and Commerce, Second Conference on Industrial Energy Conservation in Ottawa (Condensed Reports of the Industry Task Forces), (Ottawa: Industry, Trade and Commerce; and Energy, Mines and Resources, March, 1976), pp. 75-76, 33-34, and 17-19 respectively.

[10]Darmstadter, Dunkerley, and Alterman, pp. 122-125.

[11]Ibid., p. 123. Some problems, however, are encountered in the accounting procedure determining the energy intensiveness. For instance, important heat losses were excluded in the case of the electric arc method and in the case of the oxygen method, energy used in oxygen making was also excluded.

[12]This is because the historically lower price of energy would be expected to result in a more energy intensive steelmaking capacity (i.e., using the open hearth method) which is the case in Canada. This in turn is inconsistent with the lowest Canadian energy/output ratio found in this sector. Darmstadter et al. encountered a similar unresolved inconsistency in their analysis pertaining to the year 1972. See Darmstadter, Dunkerley, and Alterman, pp. 117-125.

[13]See Canada, Department of Industry, Trade and Commerce, pp. 43-46.

[14]The figures for gross domestic product generated within the transport sector, GDP_{Tr} (including transport, storage and communication), have been obtained from the cited OECD source, Table 3: Gross Domestic Product by kind of economic activity. The GDP_{Tr} figure comprises all the value of transportation and related goods and services passing through the regular market channels, but it excludes the implicit value each owner of a means of transportation (e.g., passenger car) derives from using it. As such the GDP_{Tr} is less than perfect for the purpose at hand but it is considered more appropriate than the overall GDP figure (related to the energy consumed in transport) used by Darmstadter et al. Since the objective is to relate the energy used in a particular activity to the output of the same activity, a better measure of the intensity of energy utilization in this sector is the ratio of energy used by each mode of transport over the number of passenger or freight-kilometres travelled by the same mode as adopted below. See also Chapter 4 where a similar problem arises.

[15]Note that Table 3.11 pertains to car travel only whereas in Table 3.8 the comparable category is 'road' travel. Since data related to bus and truck transport are unavailable, it is implicitly assumed here that they are roughly comparable among the selected countries or that differences among countries are not of crucial importance.

[16]Further problems arise when passenger and freight air kilometres are added to derive the figures in column 1. Certainly more appropriate data - if they were available - would be those pertaining to the load factors of both passenger and freight travel in each country. This is because the fleets of planes used by all these countries are likely to be similar and hence the differences in the ratio of energy used to distance travelled will be mainly due to the capacity utilization, the proportion of time flights are in the air, the way one defines domestic and international flights and their energy use.

[17] Similar difficulty arises here in adding passenger and freight kilometres as in the air transport. See footnote 16 above.

[18] It should be reiterated that due to the unavailability of more disaggregated data, the number of 'car-kilometres per year' (in Table 3.10) relates to passenger car travel only while the figure of the energy consumed includes all road travel, i.e., it also includes trucks and buses.

[19] Darmstadter et al. estimated that operating a car cost, in 1970, more than twice as much in Japan than in the U.S., and on the average about one and a half times more in Europe. See Darmstadter, Dunkerley, and Alterman, p. 181. Many European countries also have higher road taxes and gasoline taxes, which also contribute to higher operating costs.

[20] The change in the price of gasoline is the average of ten major Canadian cities. See Oilweek, June 18, 1979, p.16. For changes in wages and salaries, see Bank of Canada Review, May 1979, Table 52.

[21] See Oilweek, June 18, 1979, p. 14 and July 9, 1979, p. 7. The percentage changes of gasoline sales include all grades of gasoline.

[22] The concept of degree-days measures the difference between a given temperature on any day and the so-called 'threshold temperature' which is that at which heating of living space becomes necessary. If this threshold temperature is for instance $16^{o}C$ ($60.8^{o}F$) and the average temperature in one day and one location is $10^{o}C$, then six degree-days would be recorded. If the same conditions prevailed for ten days, sixty degree days would be recorded and so on. Measured in this way, the concept of degree-days concentrates on heating requirements, neglecting the aspect of cooling. This in turn will cause an upward bias in particularly the U.S. figure in column 9, Table 3.12.

[23] The actual number of degree days for each country will vary slightly every year but for the purpose of highlighting the relative differences among the countries here any recent data should suffice. The data in Table 3.12 pertain to 1972. See Darmstadter, Dunkerley, and Alterman, p. 42.

[24] See Darmstadter, Dunkerley, and Alterman, Chapter 4.

[25] Ibid., p. 48n.

CHAPTER 4

CHANGES IN THE USE OF ENERGY PER UNIT OF OUTPUT: SELECTED SECTORS, 1960 - 1976

The above brief sectoral analysis has indicated that in the recent past, important differences have existed in the levels of relative energy consumption among the selected countries. The purpose of this chapter is to show the changes in the use of energy per unit of output in each country through time. Four ratios of energy to output will be examined for each of the nine countries during the period 1960 to 1976: the overall E/GDP and the three ratios pertaining to total industry, the iron and steel (a part of total industry) and the transport sectors. The choice of these sectors has again been determined by the availability of data and the fact that when taken together, they account for between 54 and 72 percent of total final consumption of energy in the countries examined (see Table 3.1).

Rather than calculating the respective energy/output ratios for each country and then comparing them between countries (as has been done in the preceding chapter for one recent year), this chapter will attempt to show the energy/output ratios over a number of years, using each country's own currency in the process of output evaluation. This is designed to avoid the use of official exchange rates in the translation of each country's real value of output (except in the case of the iron and steel industry where physical units are used) into a common currency (the U.S. dollar).[1] The possibility of an inter-country comparison of the resulting ratios will thus be lost, but the figures obtained will more accurately reflect the changes in energy utilization through time in each country. More precisely, a declining ratio of energy to output over time will be taken as an indication of energy savings, or a progress of energy conservation, and a rising ratio will in turn suggest a heavier use of energy relative to output, i.e., the opposite of conservation.

Since the beginning of the 1960s was marked by relatively stable energy consumption, the average of the energy/output ratio for the period 1960-1965 has been set equal to an index of 100 for each country and each industry examined. Then all years following 1965 can be compared to that index to determine whether any energy savings have

been attained during the post-1965 years or whether the use of energy relative to output has become more intensive. Although the absolute energy/output ratios between countries are not comparable here, the slopes of the indices plotted for each country will be since they reflect the change of the ratio over time. This means that whenever two countries display a declining energy/output ratio, indicative of energy savings, the country whose ratio shows a steeper downward trend is saving energy at a greater rate.

On the following pages are four graphs for each of the nine countries showing the indices of the ratios of energy to output listed in the Appendix. As specified above, these ratios are: the overall E/GDP and the energy/output ratios for total industry, the iron and steel industry, and transport. Again, total industry includes manufacturing, mining, construction and utilities (including the iron and steel industry); and the transport sector includes transport, storage and communications.[2] Since these industries or sectors do not account fully for energy consumption or output in every country, it will be impossible to determine exactly for each country which sector or industry accounted for energy savings or vice versa. Nevertheless, the graphs do offer a few interesting observations which highlight the changes in the use of energy relative to output in each country between 1960 and 1976. It must, however, be pointed out that owing to their importance and dependability, data pertaining to the GDP and the total industrial sector yield more reliable results and should therefore be given a greater weight.

Let us first consider the overall E/GDP ratio which is shown for each country as the first graph. It can be seen that for all countries except the U.K., the E/GDP ratio shows a rising trend followed by a noticeable drop in 1973 (or 1972). This is interesting especially in the light of the dramatic changes of energy prices in 1973 which marked an end to the preceding period of declining real prices of energy. One possible way of explaining the rising trend of the E/GDP ratio prior to 1973 could be a factor substitution whereby the then relatively cheaper energy was being substituted for other inputs.

When examining the behaviour of the energy/output ratio over time, it may also be useful to know to what extent its value has been affected by changes in output as opposed to changes in energy consumption. This can be done by observing the percentage changes in energy use and output in Table 4.1. To avoid working with erratic changes from year to year, this table is divided into three time intervals,

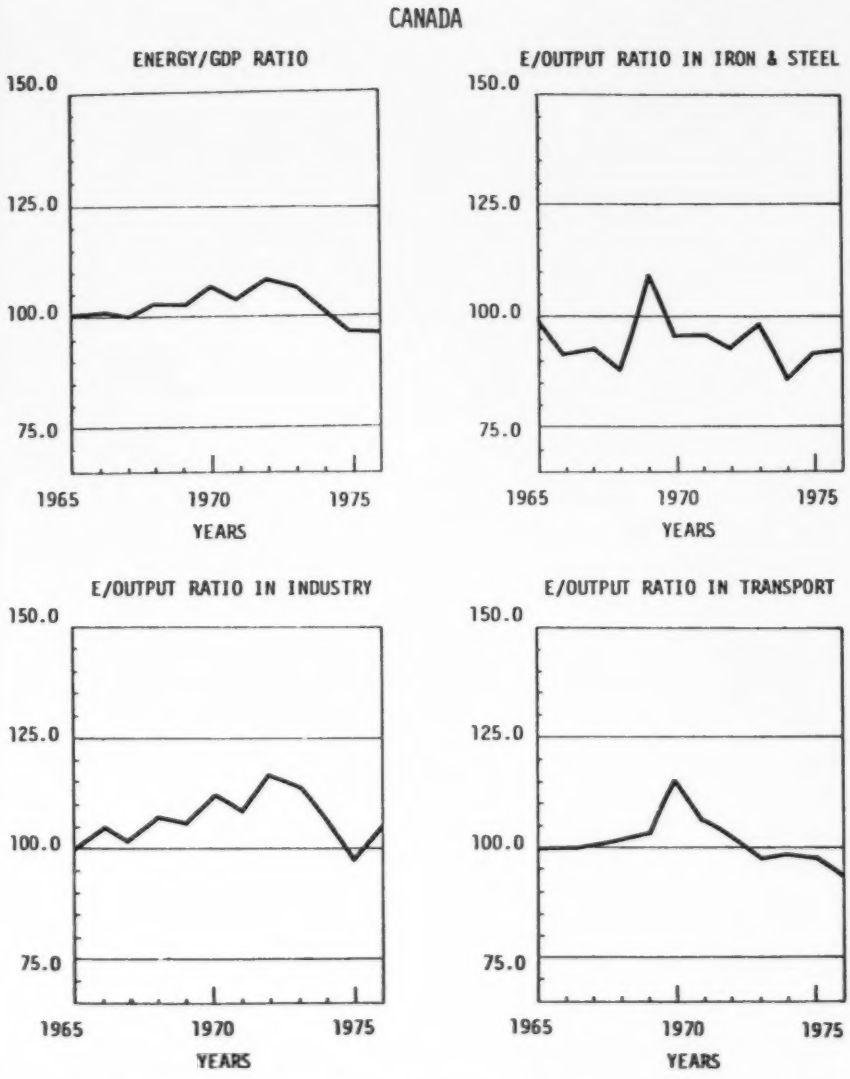

FIGURE 4.1: Canada: Energy/Output Ratios

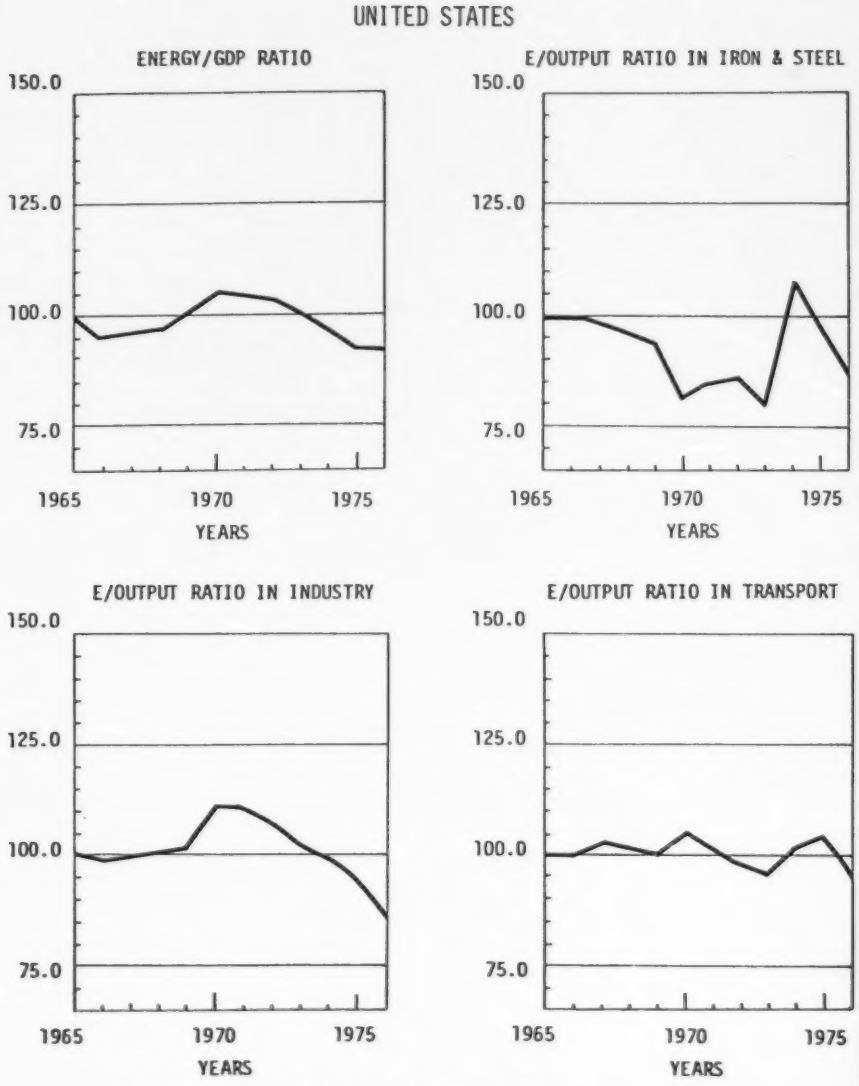

FIGURE 4.2: United States: Energy/Output Ratios

JAPAN

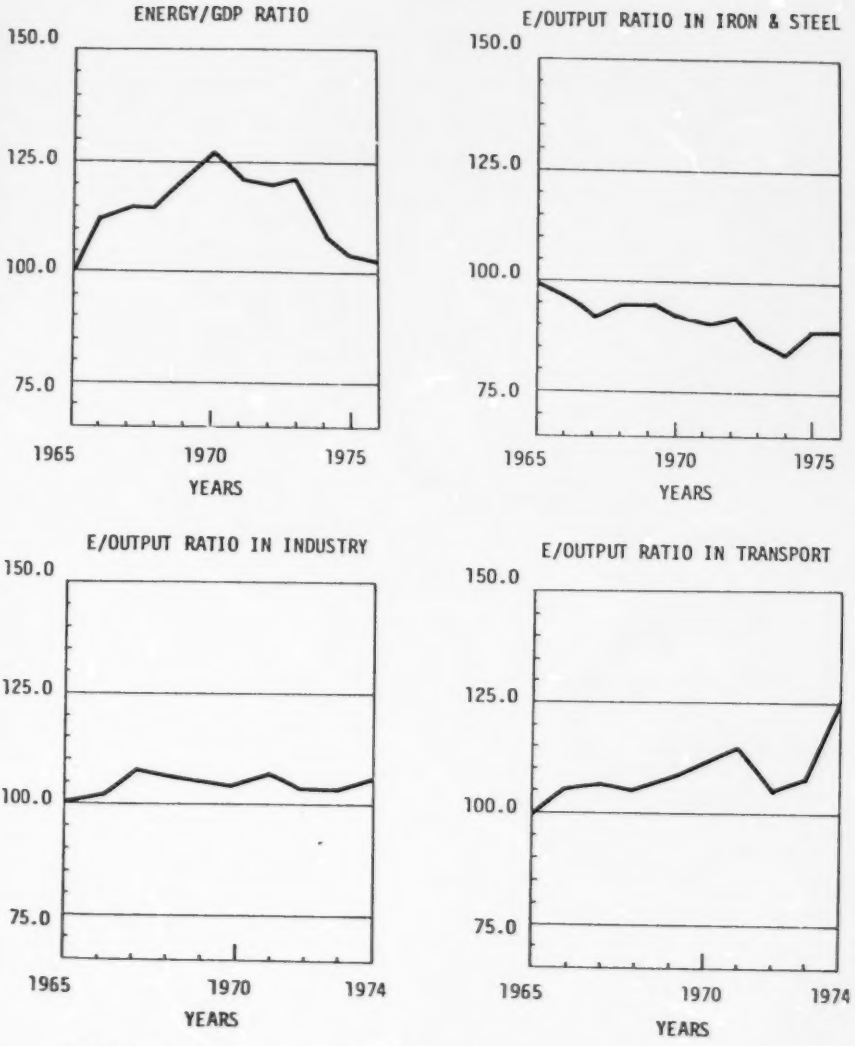

FIGURE 4.3: Japan: Energy/Output Ratios

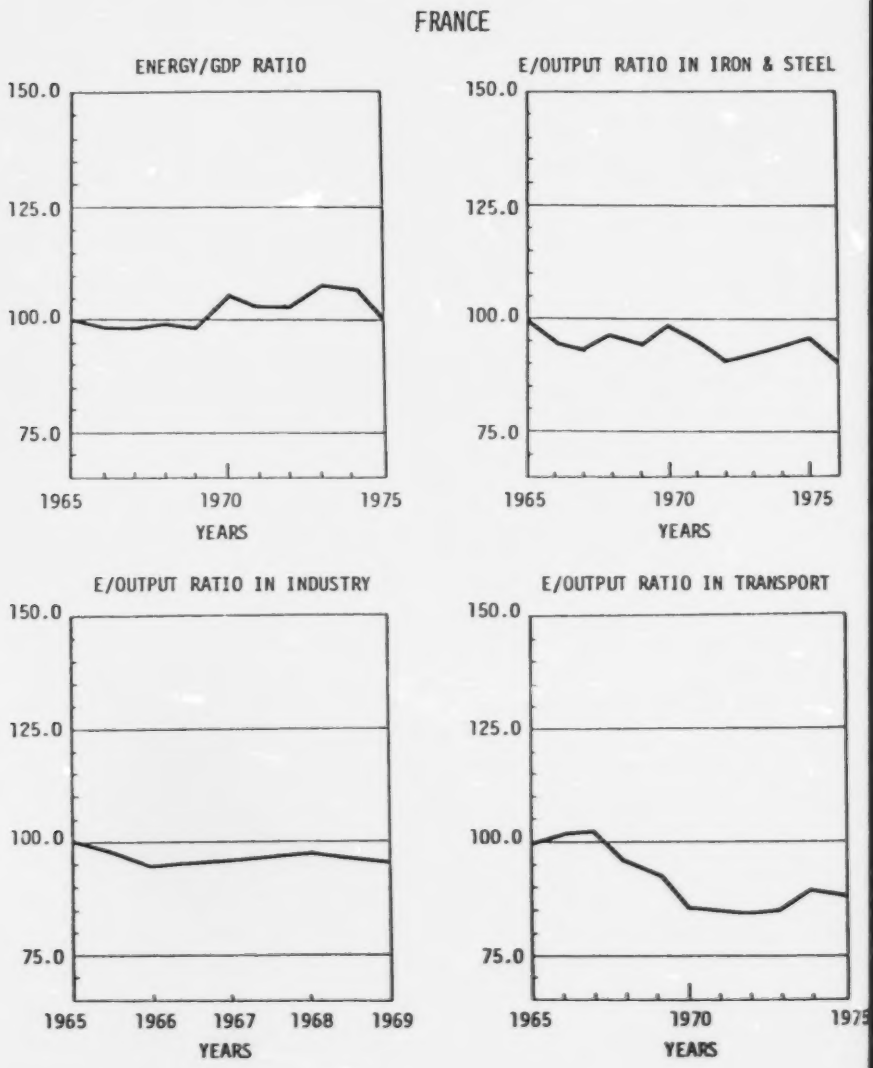

FIGURE 4.4: France: Energy/Output Ratios

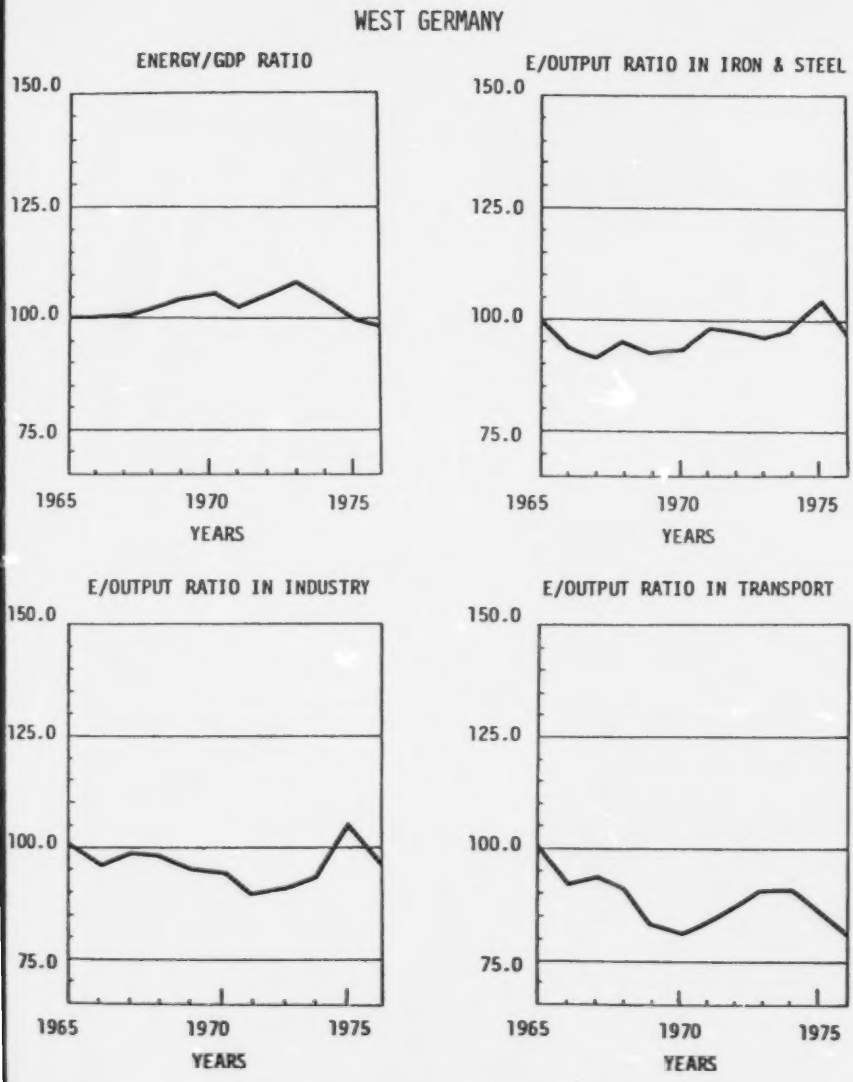

FIGURE 4.5: West Germany: Energy/Output Ratios

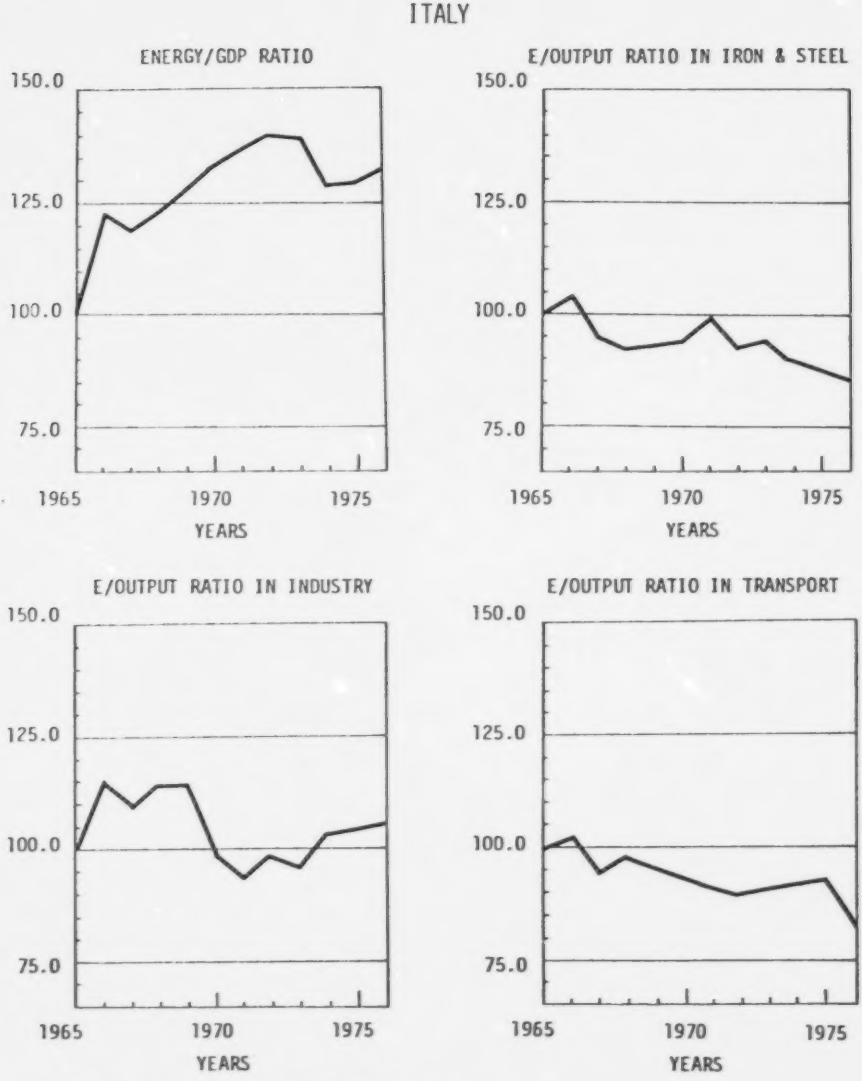

FIGURE 4.6: Italy: Energy/Output Ratios

THE NETHERLANDS

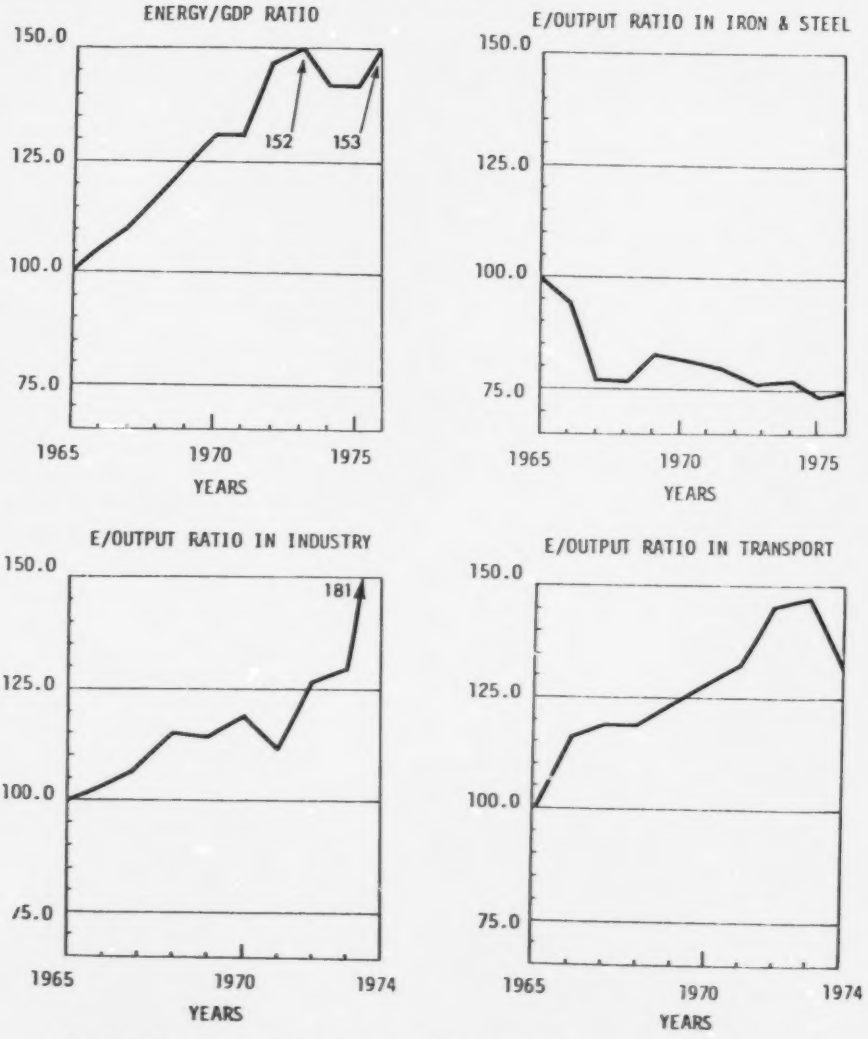

FIGURE 4.7: The Netherlands: Energy/Output Ratios

SWEDEN

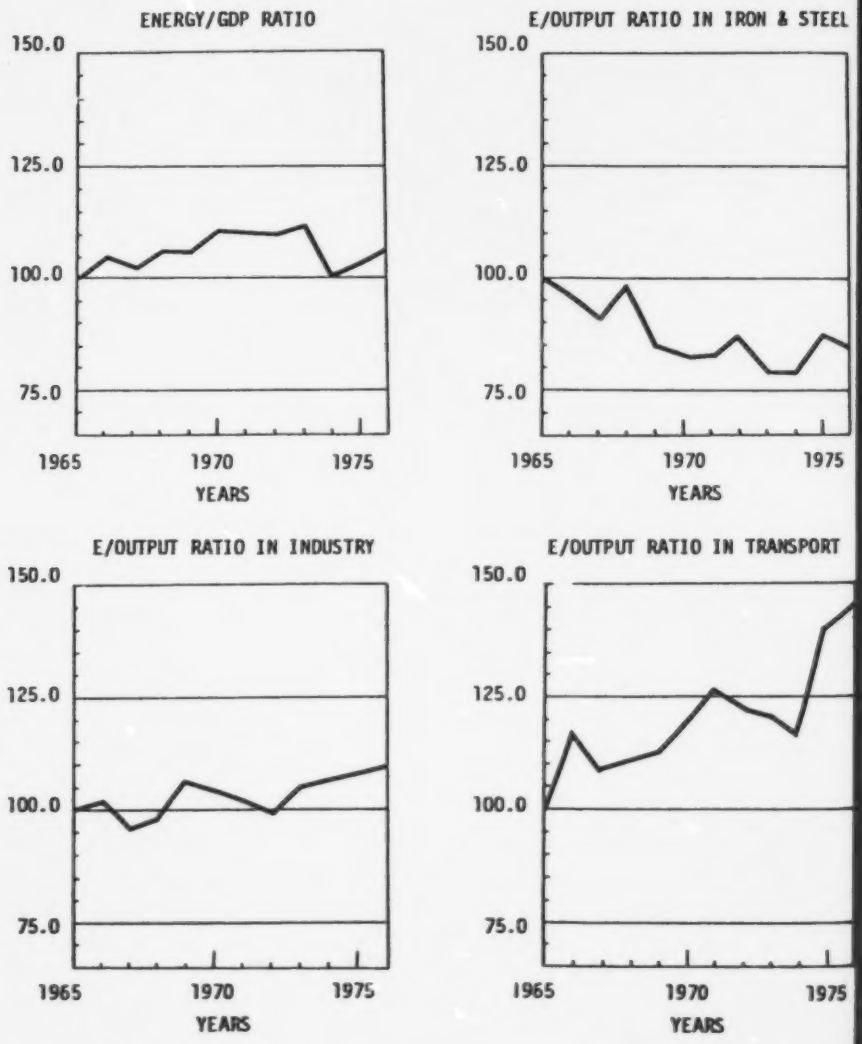

FIGURE 4.8: Sweden: Energy/Output Ratios

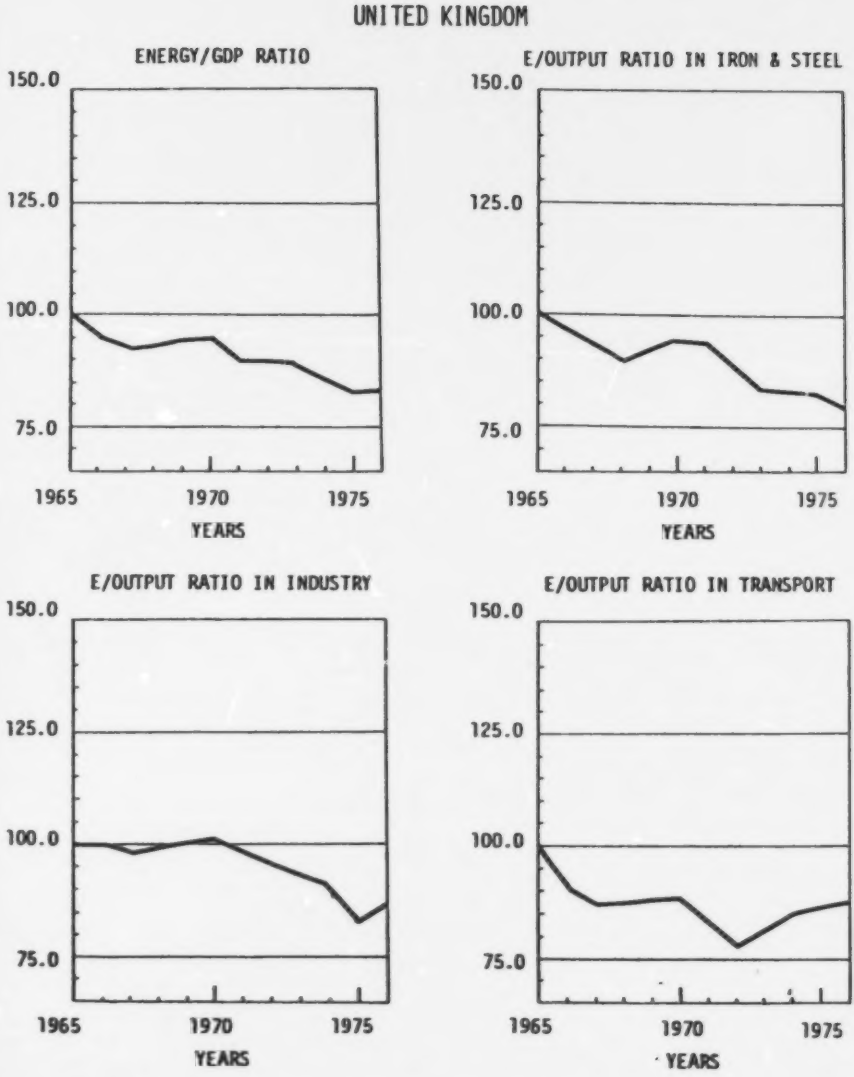

FIGURE 4.9: United Kingdom: Energy/Output Ratios

TABLE 4.1

CHANGES OF E/GDP, 1960 - 1976

		60-61	61-62	62-63	63-64	64-65	Average 1960-65	65-66	66-67	67-68	68-69	69-70	Average 1965-70	70-71	71-72	72-73	73-74	74-75	75-76	Average 1970-76
Canada	a	0.37	5.90	3.92	9.78	7.25	5.44	5.66	4.10	8.20	5.34	6.23	5.91	4.18	11.50	4.89	-1.26	-3.32	5.04	3.51
	b	3.19	6.70	5.39	6.43	6.77	5.70	6.99	3.86	5.15	5.29	2.57	4.77	6.99	5.82	7.52	3.60	0.93	5.22	5.01
	k						-.26						+1.14							-1.50
U.S.A.	a	1.86	4.98	3.78	1.78	4.89	3.46	4.80	4.34	5.50	5.46	4.64	4.97	2.20	5.36	2.26	-6.20	-4.14	6.27	0.96
	b	2.08	6.41	3.92	5.40	6.51	4.86	6.04	2.65	4.48	2.57	-0.13	3.12	2.89	5.74	5.42	-1.38	-0.88	5.84	2.94
	k						-1.40						+1.85							-1.98
Japan	a	14.04	5.40	14.45	14.96	10.80	11.93	15.18	15.47	13.28	17.56	14.81	15.26	2.81	7.98	10.42	-11.04	-2.00	5.20	2.23
	b	11.48	9.98	9.48	10.35	6.31	9.52	9.85	12.92	13.46	10.69	10.85	11.55	7.30	8.95	9.79	-1.02	2.45	5.97	5.57
	k						+2.41						+3.71							-3.34
France	a	4.03	9.18	11.74	2.95	2.86	6.15	1.50	7.18	7.28	7.28	8.59	6.37	3.26	5.75	10.86	1.62	-7.18	(2.86[c]	
	b	5.33	6.82	5.43	6.18	4.30	5.61	2.46	7.92	5.23	9.29	5.92	6.16	5.30	5.76	5.29	2.92	-1.02	(3.68[c]	
	k						+0.54						+0.21							-0.79
Germany	a	3.20	10.65	8.42	3.03	3.47	5.75	2.64	0.55	8.22	10.47	6.60	5.70	0.50	5.51	7.88	-3.05	-6.48	4.83	1.53
	b	6.49	3.84	3.66	6.46	5.18	5.13	2.51	-0.18	6.30	7.83	5.98	4.49	3.23	3.66	4.89	0.55	-2.58	5.57	2.55
	k						+0.62						+1.21							-1.02
Italy	a	8.06	11.62	12.42	5.72	9.64	9.49	15.90	3.65	9.76	9.92	9.83	9.81	4.21	5.34	6.25	-3.90	-3.15	8.38	2.86
	b	8.04	6.11	5.44	2.64	3.12	5.07	5.67	7.00	6.30	5.59	5.00	5.91	1.55	3.15	6.95	3.93	-3.62	5.63	2.95
	k						+4.42						+3.90							-0.09
Netherlands	a	5.58	15.05	13.46	4.29	6.90	9.06	3.16	9.28	12.24	11.72	14.33	10.15	3.62	17.91	7.62	-1.63	-1.21	11.48	6.30
	b	2.99	4.20	3.40	8.56	5.35	4.90	3.00	5.49	4.98	6.81	6.90	5.44	4.39	3.88	5.96	4.14	-1.17	4.67	3.65
	k						+4.16						+4.71							+2.65
Sweden	a	4.26	6.39	6.34	7.09	6.24	6.06	5.24	0.42	8.42	9.77	5.49	5.87	-1.29	2.64	6.14	-6.32	4.40	5.46	1.84
	b	5.36	4.19	5.07	6.60	5.25	5.29	2.38	3.39	4.03	5.07	4.97	3.97	0.72	2.54	3.52	3.98	0.89	1.49	2.19
	k						+0.77						+1.90							-0.35
U.K.	a	-1.12	2.46	3.30	0.21	2.93	1.56	0.24	0.55	3.80	3.44	2.10	2.03	-1.74	1.83	5.50	-4.61	-4.68	2.72	-0.16
	b	3.43	0.92	3.82	6.30	2.92	3.28	1.89	2.70	3.33	1.36	2.53	2.36	2.78	2.48	6.57	-0.68	-1.56	2.60	2.03
	k						-1.72						-0.33							-2.19

[a]Average percentage change in energy consumption.
[b]Average percentage change in (constant) output.
[c]Average only of years 1970-75.

1960-65, 1965-70, and 1970-76, for which the average percentage changes have been calculated.

By simply subtracting the percentage change in output from the percentage changes in energy consumption for a given time period, we obtain a measure 'k' which gives an indication of the relative changes in the two variables, energy and output over time. In calculating the k-values, the most common case will be that of positive percentage changes in both energy use and output, although other combinations may exist. The following are the three possible values the variable k can have.

Define: percentage change in energy use... Δe
percentage change in output ... Δo; and
$k = \Delta e - \Delta o$.

Then

(i) $k > 0$ if $\Delta e > \Delta o$ (i.e., the opposite of energy savings)
(ii) $k < 0$ if $\Delta e < \Delta o$ (i.e., energy savings or conservation attained)
(iii) $k = 0$ if $\Delta e = \Delta o$ (i.e., no changes in the use of energy)

For our purpose, the most interesting of the three possible values of k will be when k is negative. This is because when $k < 0$, the change over time in output has been greater than that in energy consumption which has been defined here as energy savings or conservation. Furthermore, the actual value of k will indicate the extent of such energy savings in each country and it will also be possible to compare the values of k between countries since it is calculated on the basis of percentage changes.[3] Hence when a country's k-value during time period one is, say, -2.0 and it is -3.0 during time period two, then it can be concluded that during the second time period, greater advances in energy savings were attained and vice versa.

Turning back to the graph of the E/GDP ratios and Table 4.1, further interesting observations can be made about the patterns of energy use in the countries examined. As mentioned above, the graphs show clearly that following 1973, all countries reduced their E/GDP ratios from the pre-1973 levels. While the slopes of the graphs indicate the rates at which energy savings have been achieved, the k-values in Table 4.1 expose the exact composition of the changes of energy use and output in each country as well as the extent of the overall change. Thus it can be seen that the time periods 1973-74 and 1974-75 were marked by (sometimes substantial) reductions in the consumption of energy and that also the period 1974-75 was characterized by a resulting slowdown of economic growth. Although in 1973 the world

price of oil had quadrupled, the figures in Table 4.1 can not be taken entirely as an indication of energy consumers' voluntary reaction to higher prices because of the accompanying oil embargo which substantially reduced the world supply of oil. The reversing trend to increased energy consumption during 1975-76 suggests that in spite of the substantial rise in the price of energy, industrial economies may need a much longer time to adjust their energy consumption patterns primarily because of the 'locked-in effect' of using a particular energy-using technology. Only when available, more recent data may reveal whether or not a more permanent downward trend of the E/GDP ratio exists. Economic theory suggests that at least in the long-run, when given the relatively more expensive energy input, factor substitution will result in more energy-efficient production processes which will lower costs and increase profits.

The average k-values for the period 1970-75 in Table 4.1 show that with the exception of the Netherlands, all countries experienced some energy savings (negative k-values). The greatest energy savings were achieved by Japan, the U.K., the U.S., and Canada.

The middle time period, 1965-70 and its average k-values show an increasing use of energy relative to output. This was a time of high level economic activity for almost all countries as well as declining real prices of energy and hence as suggested earlier, a strong incentive existed to substitute energy for other inputs of production. The average k-values in Table 4.1 show that particularly in the Netherlands, Italy, and Japan the use of energy relative to output rose substantially. Only the U.K. shows some energy savings but the yearly changes in energy use and output reveal that this middle time period was in the U.K. characterized by a relatively sluggish growth of domestic output.

During the first time period of 1960-65, Italy, the Netherlan and Japan increased considerably their energy use relative to output while the U.K., the U.S., and Canada recorded some energy savings.

Looking at the whole time interval examined (1960-76), the Canadian k-values suggest that relative to some other countries, energy savings have been attained, particularly during the most recent years, but given that in absolute terms the Canadian E/GDP ratio was found the highest of all countries, greater energy savings will be necessary to bring the Canadian ratio down.

The last observation from Table 4.1 is that the composition of changes in energy use and output suggests that in order to achieve

energy savings, or conservation as defined here, it is not necessary that a general standard of living be curtailed. All it means is that the growth of the energy consumption (i.e., the numerator of the E/GDP ratio) must be less than the growth of output (the denominator). Hence energy conservation does not imply a lowering of living standards as measured by the value of output per capita.

The next logical question after looking at the graphs of the overall E/GDP ratio is whether or not it would be possible to identify the sector or sectors which account for some of the main trends in the E/GDP ratios. This presumes that data are available for a detailed sectoral analysis of energy/output ratios over time. Since only the present data were available, through the method of elimination, at least some partial answers can be given to the question asked. These can be obtained on the basis of the other three graphs shown for each country next to the E/GDP ratio. Table 3.1 lists the percentage shares of total final consumption of energy by various sectors and it can be seen that for instance in the case of Canada, the total industrial sector accounts for 31 percent (of that, the iron and steel industry uses some 4 percent) and the transport sector for 19.3 percent. This means that 50.3 percent of the energy used in Canada is consumed by these two sectors. In the case of the U.S., the percentage is 60.9 and so on for all other countries: Japan 71.9, France 60.2, Germany 56.2, Italy 63.8, the Netherlands 53.9, Sweden 56.9, and the U.K. 56.4. Hence the three remaining graphs together account for (or 'explain') at least one half of the overall E/GDP ratio but they account for up to 72 percent in the case of Japan.

Looking first at the graphs pertaining to total industry (which includes mining, manufacturing, construction, and utilities), it is apparent that particularly in the Netherlands, but also in Italy, it is the industrial sector which accounted for their rapidly rising E/GDP ratios. On the other hand, this is not the case in Japan. Some other sector or sectors must have caused the Japanese ratio to rise so rapidly up to 1970. Since the iron and steel industry's energy/ output ratio shows a steadily declining trend, it must be the transport sector shown, personal transportation (not included in the last graph) or some others, notably the residential sector, that provided for the rapidly rising E/GDP ratio in Japan. In the case of Canada, the steadily rising industrial energy/output ratio until 1972 suggests that it accounts for some of the rising trend in the overall E/GDP ratio since the former rises more rapidly that the latter. With the exception of Italy and the Netherlands, the Canadian industrial ratio in fact rose more rapidly than that of any other country during the pre-1973 period.

This seems to support an earlier observation that relative to most other countries compared here, a potential for energy savings should exist in this sector of the Canadian economy.

The graphs of the energy/output ratios of the iron and steel industry (which is a part of total industry) surprisingly all show generally declining trends although some show rather wide fluctuations. The importance of this industry for the overall energy consumption in each country (Table 3.1) suggests that the significance of the iron and steel industry in explaining the trends of the energy/output ratios of total industry is very limited, except in the case of Japan and Germany. In both of these countries the iron and steel industry accounts for roughly one-third of the total industrial energy consumption, but only in the case of Germany is the trend of the ratio here clearly affecting the overall industrial ratio, particularly around the year 1975.

The last graph of the four shown for each country depicts the energy/output ratio of the transport sector.[4] It will be noted that unlike the first graph of the E/GDP ratios, no discernible downward trend of the ratio exists in this sector following 1973. The Netherlands, Germany, and Canada did somewhat reduce their ratios in this period but others, like Japan or Sweden, recorded a sharp increase.

Concluding Comments

This short examination of the changes of energy use per output in the three selected sectors over a longer period of time offer three interesting observations. Firstly, it is evident from the graphs showing the overall E/GDP ratios that during a period of strong economic activity and generally declining real prices of energy (the middle time period examined), a factor substitution of energy for other inputs tended to increase the E/GDP ratios. Following the oil embargo of 1973, all countries reduced their energy use relative to domestic output, but for some of them this reduction was rather short lived before the E/GDP ratio showed again a rising trend. More recent data will be needed to determine the impact of the quadrupled world oil prices upon the energy consumption with greater certainty. The underlying theory suggests that in the long-run, rising energy prices will cause the energy/output ratio to fall.

The second observation was that although Canada recently reduced her E/GDP ratio, other countries achieved a greater reduction. In the light of the fact that the Canadian ratio was found the highest

of all countries (in absolute value), this means that greater energy savings must be achieved if the Canadian E/GDP ratio is to be reduced to the level shown by other countries examined.

The third observation concerns the Canadian industrial sector. It was found that of the three sectors examined, total industry accounted for some of Canada's rising E/GDP ratio and hence that given the significance of total industry in overall energy consumption, further energy savings here will be important in reducing the overall Canadian E/GDP ratio.

Footnotes

[1]This method has been suggested by J. Gray. Since the existing exchange rates on the international markets are decided only on the basis of the activities of the foreign sector of each country, they necessarily overlook a much larger portion of each country's economic activity. The result is that often the exchange rates do not accurately reflect the purchasing power of one currency vis-a-vis another. This problem was recently highlighted in the study by I. B. Kravis et al., A System of International Comparisons of Gross Product and Purchasing Power, (Baltimore: The Johns Hopkins University Press published for The World Bank, 1975). It was estimated that for example, in 1970, $1,000 U.S. converted into pounds sterling at the official exchange rate, bought a basket of U.K. commodities 52% larger than an equal expenditure in the U.S. See Darmstadter, Dunkerley, and Alterman, p. 18.

[2]As in the preceding chapter, where this sector has been analyzed during one recent year, the problem of output evaluation arises. Again, the monetary value of output generated within the transport sector (with its acknowledged shortcomings) has been related to the amount of energy used in this sector in order to obtain a measure of sectoral intensity of energy consumption and its changes over time. See also footnote 14, Chapter 3.

[3]Thus we get around the problem of having the outputs valued at each country's own (constant) currency.

[4]It should be reiterated that the implied value of personal transportation is not included here. See also footnote 2 above.

Chapter 5

SUMMARY AND CONCLUSIONS

Three main objectives have been set for this study: (i) to see whether or not Canada is a high and wasteful user of energy; (ii) to adapt a workable definition of energy conservation and determine if any conservation potential exists in this country and can be identified; and (iii) to see what, if anything, Canada can learn from other countries through international comparison of energy use.

In pursuing these objectives it was first necessary to define what is meant by energy conservation. In order that the definition of this elusive concept is operational and allows monitoring of various intensities of energy utilization, it had to be simple. One possibility was to define conservation as the declining use of energy (E) relative to output (Gross Domestic Product or GDP). Defined in this way, energy conservation expressed in terms of a declining E/GDP ratio is synonymous with energy savings or increased energy productivity.

Although rather simple and suitable for the present purpose, the energy/output ratio has its shortcomings. The first of the two main shortcomings is that the ratio cannot be used either as an indicator of economic or energy efficiency. The ratio is concerned only with one input of production (energy) which is much less significant relative to the amounts of other inputs used (capital, labour, land, materials). Since there is no one ideal or 'correct' ratio to which all others could be compared, no meaningful judgement about economic efficiency across different countries can be passed. The intensity with which the energy input is being used will in each country be determined in an important way by that country's endowment of energy resources which in turn affects energy prices. Since economic efficiency (and hence profit) is typically achieved via selecting the least costly combination of <u>all</u> factors of production used, attempts to minimize only the energy/output ratio (or to maximize only energy productivity) will clearly be inefficient; and taking the ratio as an indicator of economic efficiency would correspondingly be incorrect. Moreover, once the relative prices of input factors change, as far as possible, one factor will be substituted for another such that the cost of production is kept at minimum. In a country like Canada, with periods of declining real energy prices, an incentive

existed to substitute energy for other inputs, thereby increasing the Canadian E/GDP ratio relative to other countries. Thus possible differentials in the energy/output ratios between countries will not suggest greater or lesser economic efficiency but rather point to potential energy savings.

The energy/output ratio will also not be a suitable measure of energy efficiency since no two countries will likely produce an output whose structure is exactly the same. Although the monetary value of outputs between two countries may be equal, quite different amounts of energy may be required to produce them (e.g., aluminum vs. light manufacturing). Ideally, as many as possible of such structural differences between two countries would have to be accounted for in order that a more exact notion of the potential for energy savings could be obtained.

The second main shortcoming of the energy/output ratio is related to the popular notion of 'wasteful' usage of energy. It should be made clear that the word 'waste' can be used without ambiguity in the present context only to the extent that it implies an extra amount of energy used in one production process producing an identical output as another process, assuming that both processes are carried out under identical conditions. This means not only identical climate, factories, productivity, etc., but also identical historical prices paid for not only energy but also all other factor inputs. Clearly, these conditions will never be fulfilled in an environment of international comparisons. Since in production (and consumption) there will always be a tendency for the cheaper input to be substituted for one which costs more, countries enjoying lower energy prices will as a rule be found using relatively more of this input and less of other inputs which are higher in price. Hence nothing can be said without ambiguity about Canada 'wasting' energy in relation to other countries which consume and produce (and have done so historically) under different economic circumstances.

These shortcomings of the E/GDP ratio notwithstanding, at least three ways were identified in which the ratio could be useful:

(i) in revealing that different amounts of energy will be used to produce a given output which in turn points to sectors worthy of further study to assess the conservation potential;

(ii) in illustrating the effects of different energy prices across countries on their levels of energy use; and

(iii) in indicating the rate at which energy is being saved by examining the changes of the ratio over time.

For the present purpose, this means that whenever a Canadian energy/output ratio is found greatly in excess of a similar ratio pertaining to a different country, an energy saving potential can be said to exist in Canada.

Following the establishment of the energy/output ratio as the monitoring agent of the various levels of energy consumption, sectoral analysis of selected industries were adopted in order to determine the level of energy utilization in Canada relative to eight other industrial countries for which data were available (the U.S., Japan, France, West Germany, Italy, the Netherlands, Sweden, and the U.K.). Since the examination of the overall E/GDP ratios revealed that this ratio was higher in Canada than in any other of the selected countries, further analysis was thought desirable to determine which Canadian sectors or industries might account for this apparently high intensity of energy use in this country. First, a group of industries in each country and their energy use relative to output were analyzed for one recent year, and then a smaller group of industries and their energy utilization were examined during an extended period of time.

The sectoral analysis began with a look at the industrial sector as a whole during 1976; it included mining and quarrying, manufacturing, construction and the utilities. It was found that two countries, Germany and France, displayed significantly lower energy/output ratios in their industrial production when compared with Canada. Although a more detailed analysis of these two countries and Canada revealed that indeed the structure of the Canadian industrial output bears characteristics of being more energy intensive, the structural differences did not appear sufficient to account for the large differences found in the energy/output ratios. The analysis also showed that some Canadian industries--the petroleum products groups, crude steel, and pulp and paper--use significantly more energy per unit of output and hence that at least in the production of these commodities an energy savings potential exists in Canada. This potential has further been acknowledged by spokesmen of the cement and pulp and paper industries as well as for other parts of the manufacturing industry. It must be recognized, however, that the lower energy/output ratios displayed by the industrial sectors of other countries are largely a result of historically higher prices paid for major forms of energy by industry in those countries. It is therefore not possible to expect great and fast improvements in energy use in Canada unless the Canadian

prices move upwards, closer to the levels experienced in Japan or in Europe.

The iron and steel, chemical and petrochemical industries are parts of the total industry group but data availability made it possible to examine them separately. It was found that in the iron and steel industry, in 1975 the Canadian ratio of energy used to produce one ton of pig-iron, crude steel and ferro-alloys all taken together, was the lowest of all countries. Since as mentioned above, Canada was also found to use more energy than any other country in the production of crude steel alone, it must be that in turn Canada used less energy than most countries in the production of pig-iron and ferro-alloys. Although the output of this industry is more homogeneous among all countries than the total output of the industrial sector, important differences exist in the types of technology employed and the quality of iron ores used. These differences together with the differentials found in the price of energy among countries account for the variations of the energy/output ratios in this industry.

The chemical and petrochemical industry does not account for a large portion of the total Canadian energy consumption but a potential for energy savings here was revealed, at least when Canada was compared with the U.S. The existence of this potential has also been confirmed by the Canadian chemical industry task force which put forward a target of 17 percent reduction in its energy use per unit of output by 1980, relative to the base year of 1972.

Clearly the most interesting and revealing of this brief sectoral analysis was that of the transport sector. It was found that Canada and the U.S. consume energy relative to distance travelled at approximately twice the rate when compared with Japan and the European countries. It was also found that of the three modes of transportation considered, air, rail, and road, it was the road travel where most of the difference between Canada and the European countries and Japan originated. The international comparison of this sector leaves no doubt that significant energy savings in Canada are possible, although probably not in relation to the historically much lower prices of gasoline and other energy products used in transport. This last condition, however, holds not only for this sector but also for all other sectors under consideration. It is important to realize that the relatively long period of low (and sometimes even declining) prices of energy in Canada seems to have come to an end earlier in this decade, and that it will now take some time before consumers of energy start responding to the changed economic conditions. Since the potential for

energy savings found in the transport sector in Canada is much larger relative to other sectors and since this sector accounts for a large portion of the overall energy use, savings of energy attained here will be significant in lowering the overall Canadian E/GDP ratio.

Also in the residential or household sector, an energy saving potential was found to exist in this country. Because it is difficult to identify ouput of the residential sector, energy consumed per dwelling was used to indicate the intensity of energy utilization in each country. When the concept of degree-days was used to account for the differences in climate among all countries, it was revealed that at least four of them used less energy per dwelling than Canada by between 9 and 21 percent. Because of the relative importance of the residential sector in total energy consumption in all countries, an improvement in this sector would also significantly help to lower the Canadian E/GDP ratio.

The second part of the analysis involved an examination of the energy/output ratios during the period from 1960 to 1976. The availability of data limited the analysis only to four ratios: the overall E/GDP and the energy/output ratios in total industry, iron and steel, and the transport sectors. Of these four ratios, the E/GDP and the ratio of energy to output in total industry yielded more interesting and reliable results owing to their relative importance and also to the availability of more dependable data. A slightly different method was used in this international comparison of the time-series data. Each country's average of all four energy/output ratios for the stable period of 1960-1965 was set equal to 100 to which the ratios of all subsequent years were then compared to see the trends of energy utilization in each country. This eliminated the problem of having to translate the value of output in each country to a common currency in order that the energy/output ratios were comparable. Expressing the ratios for each country in this index form cancelled the possibility of an intercountry comparison of the absolute values of these ratios, but when plotted, the shapes of the resulting graphs show the progress (or vice versa) of energy saving in each country, and the slopes of the graphs (which are directly comparable) reflect the rates at which energy was saved over time.

When analyzing the behaviour of the energy/output ratios through time, it was also thought useful to know the relative changes of energy use (the numerator) and output (the denominator). A simple method of comparing the percentage changes of both energy consumption and output was suggested which made it possible to numerically evaluate

two different ways of reducing (increasing) the use of energy relative to output.

Three general observations resulted from the short examination of the changes of energy use over time. The first observation was that of factor substitution of energy for other inputs during the time period characterized by a strong economic activity and generally declining real prices of energy. This was reflected in rising E/GDP ratios and the industrial energy/output ratios prior to 1973. After the dramatic events in the world oil market in 1973, all countries reduce their energy use relative to domestic output, although for some of them this reduction seems to have been only temporary, followed again by a rising trend of the E/GDP ratio. Only when more recent data become available will it be possible to determine with greater certainty what impact the quadrupling of world oil prices has had on the long-term trend of energy consumption relative to output. The underlying theory suggests that rising prices of energy will cause the energy/output ratio to fall.

The second observation concerned the rate of attained energy savings in Canada relative to other countries. It was found that although some reduction of the E/GDP ratio has been achieved in this country, other countries recorded energy savings that were higher. This means that since the Canadian E/GDP ratio was the highest of all countries examined, higher energy savings will be needed in order to bring the Canadian ratio down to the level exhibited by other countries examined here.

The third observation suggested the importance of the Canadian industrial sector for energy savings. It was found that the total industrial sector accounted for some of Canada's rising E/GDP ratio and that given the importance of total industry in overall consumption of energy, further energy savings attained here would be significant in reducing the overall Canadian E/GDP ratio. The next important question is how the savings of energy either in the Canadian industrial sector or elsewhere in the economy could be achieved.

This brings us back to one of the objectives set for this study, namely what, if anything, can Canada learn from an international comparison of energy use. The one thing which has become apparent is that if countries experiencing generally much higher levels of energy prices show also much lower energy/output ratios, then the existence of the generally asserted positive relationship between the price of energy and the use of it seems confirmed. Good economic reasons have been shown to exist in Canada (and the U.S.) in relation to the other

countries examined here (i.e., the relative abundance of indigenous energy supplies giving rise to a comparative advantage which in turn explains lower energy prices), which can explain the existence of higher relative use of energy in this country. This suggests that one possible way of achieving greater savings of energy, leading to a reduction of the Canadian E/GDP ratio, is via higher prices of energy. Given the fact that the domestic prices of major energy products (oil, gasoline, natural gas, electricity) are regulated, a mechanism already exists for instituting higher prices. It is well known that rising energy prices make a wider variety of alternative energy sources economically viable, witness the oil sands in Canada or the plans to develop the oil shale deposits in the U.S. A frequent hope has been expressed, however, that a major technological breakthrough will greatly enhance the production of oil from oil sands or heavy oils, making the oil sands plants utilizing presently available technology too expensive and obsolete. Clearly, a major technological breakthrough would be required. Since to this day all existing oil sands plants plus the one in the planning stage by Shell et al. utilize--although with modifications--the separation process first developed by Dr. K. Clark in the 1920s, waiting for a major breakthrough may prove disappointing. Hence raising the domestic prices of energy to world levels, though perhaps politically unpopular, would have two distinctly desirable effects: it would help to realize some of the energy saving potential which was found to exist in this country, and it would also make the development of alternative energy sources (oil sands, heavy oils, tidal power, solar energy, etc.) economically viable.

As for the recent popular incriminations that relative to other countries Canada 'wastes' energy, (which are normative statements with selectively appealing ethical connotations) unless the term 'waste' is properly defined such statements can be greatly misleading. One could then for instance say that India or China 'waste' labour since their production can generally be described as much more labour intensive when compared with Canada. Since in both of these countries labour is abundant and therefore cheaper relative to, say, capital, more of labour is being used in production. If for some reason labour suddenly became scarce or more expensive, an incentive would arise to substitute for labour the now relatively cheaper other inputs. This change in relative prices would open the door for savings of labour which could subsequently be used elsewhere in the economy. Analogously, in Canada a potential for savings of the energy input now exists, particularly in the transport, residential and the industrial sectors. It was one of the findings of this inquiry that one way of realizing this energy saving potential could be through higher energy prices.

APPENDIX A

TABLE A.1

ENERGY/GDP: ENERGY USED PER CONSTANT 1970 DOMESTIC OUTPUT
(local currency)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	1.	62.67	62.90	66.61	69.22	75.99	81.50	86.11	89.64	96.99	102.17	108.54	113.08	126.08	132.25	130.58	126.25	132.61
	2.a	51,903	53,558	57,149	60,288	64,166	68,509	73,299	76,131	80,049	84,296	86,454	92,498	97,881	105,246	109,040	110,051	115,801
	3.	1.21	1.17	1.17	1.15	1.18	1.19	1.18	1.18	1.21	1.21	1.26	1.22	1.29	1.26	1.20	1.15	1.15
U.S.A.	1.	810.15	825.19	866.29	899.02	915.03	959.73	1006.73	1050.42	1108.17	1168.65	1222.88	1249.76	1316.79	1346.53	1263.09	1210.84	1286.71
	2.b	664.50	678.30	721.80	750.10	790.70	842.20	893.10	916.80	957.90	982.50	981.20	1009.60	1067.60	1125.50	1110.00	1100.20	1164.50
	3.	1.22	1.22	1.20	1.20	1.16	1.14	1.13	1.15	1.16	1.19	1.25	1.24	1.23	1.20	1.14	1.10	1.10
Japan	1.	61.27	69.87	73.64	84.28	96.89	107.35	123.65	142.78	161.74	190.14	218.30	224.43	242.33	267.59	238.04	233.27	245.41
	2.b	26,064	29,055	31,954	34,983	38,603	41,040	45,081	50,904	57,757	63,929	70,867	76,041	82,846	90,959	90,030	92,237	97,746
	3.	2.35	2.41	2.31	2.41	2.51	2.62	2.74	2.81	2.80	2.97	3.08	2.95	2.93	2.94	2.64	2.53	2.51
France	1.	63.47	66.03	72.09	80.55	82.93	85.30	86.58	92.80	98.56	106.81	115.98	119.76	126.65	140.40	142.68	132.43	136.61
	2.b	463.60	488.30	521.60	549.90	583.90	609.00	624.00	673.40	708.60	774.40	782.56	824.01	871.45	917.53	944.36	934.69	NA
	3.	136.91	135.22	138.21	146.48	142.03	140.07	138.75	137.81	140.50	137.93	148.21	145.34	145.33	153.02	151.09	141.68	NA
Germany	1.	102.13	105.40	116.63	126.45	130.28	134.80	138.36	139.12	150.56	166.32	177.30	178.18	188.00	202.82	196.63	183.89	192.77
	2.b	425.50	453.10	470.50	487.70	519.20	546.10	559.80	558.80	594.00	640.50	678.80	700.70	726.30	761.80	766.00	746.20	787.80
	3.	240.02	232.62	247.89	259.28	250.92	246.84	247.16	248.96	253.47	259.67	261.20	254.29	258.85	266.24	256.70	246.44	244.69
Italy	1.	36.24	39.16	43.71	49.14	51.95	56.96	66.03	68.44	75.12	82.57	90.69	94.51	99.56	105.78	101.65	98.45	106.70
	2.b	33,986	36,719	38,961	41,082	42,165	43,480	45,944	49,159	52,257	55,176	57,937	58,836	60,689	64,905	67,455	65,086	68,752
	3.	1.07	1.07	1.12	1.20	1.23	1.31	1.44	1.39	1.44	1.50	1.57	1.61	1.64	1.63	1.51	1.51	1.55
Neth.	1.	15.23	16.08	18.50	20.99	21.89	23.40	24.14	26.38	29.61	33.08	37.82	39.19	46.21	49.73	48.92	48.33	53.88
	2.b	69.32	71.39	74.40	76.92	83.51	87.98	90.61	95.59	100.35	107.18	114.57	119.60	124.24	131.64	137.10	135.49	141.82
	3.	220	225	249	273	262	266	266	276	295	309	330	328	372	378	357	357	380
Sweden	1.	18.76	19.56	20.81	22.13	23.70	25.18	26.50	26.61	28.85	31.67	33.41	32.98	33.85	35.93	33.66	35.14	37.06
	2.b	108.74	114.57	119.37	125.42	133.70	140.71	144.10	148.93	154.93	162.79	170.88	172.11	176.52	182.74	190.02	191.71	194.56
	3.	173	171	174	176	177	180	184	179	186	195	196	192	192	197	177	183	190
U.K.	1.	122.68	121.30	124.29	128.39	128.66	132.43	132.75	133.48	138.54	143.30	146.31	143.76	146.39	154.44	147.32	140.42	144.25
	2.a	38,431	39,748	40,113	41,645	43,854	45,135	45,990	47,234	48,808	49,473	50,724	52,134	53,425	56,933	56,544	55,661	57,106
	3.	3.19	3.05	3.10	3.08	2.93	2.93	2.89	2.83	2.84	2.90	2.88	2.76	2.74	2.71	2.61	2.52	2.53

SOURCES: OECD, National Accounts of OECD Countries, Paris, various editions.
OECD, Energy Balances of OECD Countries, Paris, 1976 and 1978 editions.

NOTES: 1. Energy used (mtoe)
2. GDP (\$million or \$billion of local currency)
3. TTOE ÷ GDP

TABLE A.2

ENERGY/GDP: INDEX OF ENERGY USED PER CONSTANT 1970 DOMESTIC OUTPUT
(local currency)

Country	1960-1965 Average Ratio	Index	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76
Canada	1,178.16	100	101	100	103	103	107	104	109	107	102	97	97
United States	1,188,541.30	100	95	96	97	100	105	104	104	101	96	93	93
Japan	2,432.60	100	113	115	115	122	127	121	120	121	109	104	103
France	139,819.16	100	99	99	100	99	106	104	104	109	108	101	NA
West Germany	246,261.83	100	100	101	103	105	106	103	105	108	104	100	99
Italy	1,165.30	100	123	119	123	128	134	138	141	140	129	130	133
Netherlands	249.16	100	107	111	118	124	132	132	149	152	143	143	153
Sweden	175.16	100	105	102	106	106	111	110	110	112	101	104	108
United Kingdom	3,048.83	100	95	93	93	95	95	90	90	89	85	83	83

TABLE A.3

TOTAL INDUSTRY: ENERGY USED PER CONSTANT 1970 OUTPUT
(local currency)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	1.	21.37	20.51	21.09	21.10	24.10	26.53	27.94	28.03	30.96	32.53	34.75	35.53	40.96	43.13	41.96	37.16	41.14
	2.a	17,739	18,073	19,383	20,472	21,937	23,986	23,838	24,766	25,700	27,238	27,421	29,125	30,953	33,510	34,651	33,514	34,874
	3.	1.21	1.14	1.09	1.03	1.10	1.21	1.18	1.16	1.21	1.19	1.27	1.22	1.32	1.29	1.21	1.11	1.18
U.S.A.	1.	272.20	271.83	284.35	295.62	315.81	330.62	345.05	351.43	370.61	388.34	400.96	402.20	420.81	427.37	394.48	350.91	357.91
	2.a	251,305	254,796	271,778	281,321	297,747	307,200	326,000	330,600	349,200	357,800	380,400	384,100	389,400	395,800	373,000	351,800	384,700
	3.	1.08	1.07	1.05	1.05	1.06	1.08	1.06	1.06	1.06	1.09	1.18	1.17	1.14	1.08	1.06	1.00	0.93
Japan	1.	36.55	41.74	41.54	47.12	50.65	54.05	61.01	74.89	83.41	96.41	107.77	109.62	115.27	127.08	131.09	125,300	133,320
	2.b	11,000	12,712	13,695	15,347	16,867	17,027	18,393	22,084	24,926	28,960	32,517	32,466	35,196	40,531	39,083	NA	NA
	3.	3.32	3.28	3.03	3.07	3.00	3.17	3.31	3.39	3.35	3.34	3.31	3.37	3.28	3.14	3.35	NA	NA
France	1.	29.12	30.09	31.56	33.84	36.22	37.76	38.32	39.96	42.76	46.06	49.83	46.69	46.27	48.94	56.35	49.29	52.42
	2.a	222,758	236,194	247,550	262,062	283,565	295,313	313,345	325,969	339,368	371,825	383,870	370,330	380,240	399,120	370,430	356,650	380,898
	3.	131	127	127	129	128	128	122	123	126	124	164	146	136	136	152	138	138
Germany	1.	48.53	48.45	49.97	51.20	55.43	56.80	55.77	56.02	60.17	64.16	67.69	66.32	68.68	75.52	83.87	72.05	73.83
	2.a	231,632	247,351	255,750	260,875	279,692	286,260	291,550	284,150	307,880	339,720	360,710	369,690	387,360	403,040	399,950	375,590	NA
	3.	210	196	195	196	198	198	191	197	195	189	188	179	180	187	210	192	NA
Italy	1.	17.29	18.45	20.85	23.25	24.09	26.25	28.81	29.53	33.35	35.81	38.85	37.01	40.15	43.16	48.36	44.41	49.76
	2.b	11,436	12,439	13,301	14,191	14,451	14,520	15,403	15,571	16,009	19,352	24,458	24,362	25,489	27,515	28,786	26,217	28,758
	3.	1.51	1.48	1.57	1.64	1.67	1.81	1.87	1.78	1.85	1.85	1.59	1.52	1.59	1.57	1.68	1.69	1.73
Neth.	1.	5.68	5.72	6.19	6.75	7.22	7.70	7.94	8.58	9.91	10.66	11.68	11.45	13.64	14.47	21.06	18.28	20.82
	2.a	26,972	27,596	28,219	28,817	31,522	32,378	34,540	36,171	38,469	42,506	44,539	46,089	47,705	50,078	52,428	NA	NA
	3.	211	207	219	234	229	231	230	240	257	255	262	248	284	289	402	NA	NA
Sweden	1.	8.70	8.76	8.97	9.29	10.02	10.22	10.62	10.41	11.26	13.09	13.40	13.11	13.12	14.66	15.32	15.23	15.42
	2.a	41,497	43,941	47,018	48,896	52,971	53,615	53,033	54,962	57,869	62,185	65,286	65,115	66,911	70,737	72,478	71,560	71,066
	3.	210	199	191	190	189	191	200	189	195	210	205	201	196	207	211	213	217
U.K.	1.	48.28	48.14	47.80	48.72	51.20	52.83	52.58	51.79	53.30	54.89	56.17	54.61	54.95	58.15	56.35	49.24	52.42
	2.a	16,366	16,534	16,453	16,965	18,108	18,413	18,251	18,229	18,704	19,076	19,250	19,276	19,411	21,324	21,425	20,509	20,890
	3.	2.95	2.91	2.91	2.87	2.83	2.87	2.88	2.84	2.85	2.88	2.92	2.83	2.77	2.73	2.63	2.40	2.51

SOURCES. OECD, National Accounts of OECD Countries, Paris, various editions.
OECD, Energy Balances of OECD Countries, Paris, 1976 and 1978 editions.

NOTES. 1. Energy used (mtoe)
2. Output (million or billion of local currency)
3. TOE / output

TABLE A.4

TOTAL INDUSTRY: INDEX OF ENERGY USED PER CONSTANT 1970 OUTPUT
(local currency)

Country	1960-1965 Average Ratio	Index	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76
Canada	1,128.50	100	105	102	107	106	112	108	117	114	107	98	105
United States	1,064.00	100	99	100	100	102	111	110	107	102	99	94	87
Japan	3.15	100	102	108	107	106	105	107	104	104	107	NA	NA
France	128.30	100	95	96	98	97	NA	NA	NA	NA	NA	NA	NA
West Germany	198.83	100	96	99	98	95	95	90	91	94	106	97	NA
Italy	1.61	100	116	110	115	115	99	94	99	97	104	105	107
Netherlands	221.83	100	104	108	116	115	120	112	128	130	181	NA	NA
Sweden	196.16	100	102	96	99	107	105	102	100	106	103	109	111
United Kingdom	2,889.16	100	100	98	99	100	101	98	96	94	91	83	87

TABLE A.5

IRON AND STEEL: ENERGY USED PER OUTPUT

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	1.	9,295	10,480	11,419	12,940	14,374	15,714	15,789	15,247	17,908	16,304	19,622	19,050	20,581	21,123	24,039	22,897	23,163
	2.	2,510	2,700	2,800	3,010	3,180	3,430	3,500	3,410	3,790	4,300	4,510	4,390	4,590	5,010	4,980	5,060	5,170
	3.	.270	.258	.245	.233	.221	.218	.222	.224	.212	.264	.230	.230	.223	.237	.207	.221	.223
U.S.A.	1.	152,317	149,441	150,560	166,118	195,042	201,740	206,934	196,569	202,145	216,688	204,450	184,987	203,736	230,905	195,240	180,332	194,925
	2.	52,080	50,940	50,720	53,730	60,610	62,500	67,530	63,140	63,520	65,740	54,070	51,390	57,040	59,690	69,280	56,470	55,470
	3.	.342	.341	.337	.323	.311	.310	.326	.321	.314	.303	.264	.278	.280	.259	.355	.313	.285
Japan	1.	34,479	44,651	45,985	51,935	64,249	69,321	80,528	103,194	114,356	141,611	163,046	167,967	172,699	211,375	209,835	191,329	195,983
	2.	10,340	12,850	12,950	14,980	16,850	18,530	22,000	26,720	30,660	37,760	42,340	43,020	44,470	51,610	49,810	47,860	48,720
	3.	.300	.288	.282	.288	.262	.267	.273	.259	.268	.267	.260	.256	.258	.244	.237	.250	.249
France	1.	31,646	32,386	31,409	32,064	35,862	35,629	35,439	35,640	37,150	41,050	43,348	41,578	43,449	46,015	49,990	39,845	42,733
	2.	10,200	10,290	10,130	10,370	11,180	11,110	10,740	10,640	11,470	12,450	13,690	12,690	12,630	13,790	15,080	12,180	12,260
	3.	.322	.318	.323	.323	.312	.312	.303	.299	.309	.303	.316	.305	.291	.295	.302	.306	.287
Germany	1.	59,990	59,037	56,926	54,611	64,652	64,007	60,900	64,271	71,673	79,228	78,937	70,537	75,926	86,614	93,735	70,744	74,503
	2.	19,010	18,600	17,970	16,940	18,810	18,260	17,480	18,120	20,730	22,520	22,550	21,030	22,460	25,310	28,130	22,450	21,600
	3.	.317	.315	.316	.310	.291	.285	.287	.282	.289	.284	.286	.298	.296	.292	.300	.317	.290
Italy	1.	11,053	12,325	13,435	14,025	13,418	18,312	20,056	23,354	24,956	24,375	25,806	26,179	29,449	31,266	35,738	33,159	35,334
	2.	3,310	3,410	3,690	4,000	3,930	5,470	6,040	6,380	6,720	6,640	7,030	7,530	7,920	8,440	9,300	8,370	8,660
	3.	.299	.277	.275	.285	.293	.299	.301	.273	.269	.272	.272	.288	.269	.270	.260	.252	.245
Neth.	1.	3,288	3,427	3,658	4,050	4,593	5,502	5,465	5,990	6,528	. .	8,636	8,842	9,874	10,332	10,644	9,121	9,455
	2.	1,190	1,220	1,330	1,410	1,680	1,780	1,750	1,610	1,750	2,360	2,470	2,490	2,700	2,750	2,850	2,340	2,480
	3.	.362	.356	.364	.348	.336	.324	.330	.269	.268	.288	.286	.282	.273	.266	.268	.257	.262
Sweden	1.	4,844	5,456	5,571	5,916	6,780	7,169	7,153	7,327	7,771	8,145	8,336	8,078	7,835	8,433	9,153	9,121	8,364
	2.	1,660	1,810	2,020	2,110	2,290	2,270	2,370	2,270	2,630	2,350	2,370	2,300	2,320	2,270	2,470	2,730	2,430
	3.	.343	.332	.363	.357	.338	.317	.331	.310	.338	.289	.284	.285	.296	.269	.270	.299	.291
U.K.	1.	40,711	37,424	34,732	37,708	44,202	45,180	40,668	39,675	42,972	43,499	45,993	39,590	40,638	43,680	36,542	32,536	36,298
	2.	16,180	15,440	14,450	15,020	16,630	17,010	15,600	14,750	15,380	16,070	16,330	14,770	14,150	14,530	12,000	10,580	11,460
	3.	.397	.413	.416	.398	.376	.376	.384	.372	.358	.369	.375	.373	.348	.333	.328	.325	.316

SOURCES: OECD, Energy Balances of OECD Countries, Paris, 1976 and 1978 editions.

UN, Statistical Yearbook 1976, New York, 1977.

NOTES: 1. Output, thousand metric tons;
2. Energy used in iron and steel industry, TTOE;
3. Energy/output ratio, (2) ÷ (1).

TABLE A.6

IRON AND STEEL: INDEX OF ENERGY USED PER OUTPUT

Country	1960-1965 Average Ratio	Index	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76
Canada	240.83	100	92	93	88	110	96	96	93	98	86	92	93
United States	327.30	100	100	98	96	93	81	85	86	79	108	96	87
Japan	281.16	100	97	92	95	95	92	91	92	87	84	89	89
France	318.30	100	95	94	97	95	99	96	91	93	95	96	90
West Germany	305.60	100	94	92	95	93	94	98	97	96	98	104	95
Italy	288.00	100	105	95	93	94	94	100	93	94	90	88	85
Netherlands	348.30	100	95	77	77	83	82	81	78	76	77	74	75
Sweden	341.60	100	97	91	99	85	83	83	87	79	79	88	85
United Kingdom	396.00	100	97	94	90	93	95	94	88	84	83	82	80

TABLE A.7

TRANSPORT SECTOR: ENERGY USED PER CONSTANT 1970 OUTPUT
(local currency)

		1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
Canada	1.	16.01	16.35	17.34	18.01	19.17	20.28	21.68	22.83	24.12	25.32	27.47	28.77	30.65	33.07	35.11	36.74	37.80
	2.a	4,534	4,676	5,078	5,456	5,816	6,022	6,353	6,649	7,009	7,253	7,025	8,015	8,830	10,022	10,564	11,178	11,904
	3.	3,531	3,497	3,415	3,301	3,296	3,368	3,413	3,434	3,441	3,491	3,910	3,590	3,471	3,300	3,324	3,287	3,175
U.S.A.	1.	234.26	239.04	250.85	260.69	267.21	277.50	289.61	302.78	324.23	337.25	348.55	364.38	387.27	404.08	399.86	412.18	425.82
	2.a	65,320	63,191	68,726	72,429	74,677	76,132	79,412	80,778	88,551	92,537	90,950	99,449	108,978	116,086	107,246	109,252	121,310
	3.	3,586	3,783	3,650	3,599	3,578	3,645	3,647	3,748	3,662	3,644	3,832	3,664	3,554	3,481	3,728	3,773	3,510
Japan	1.	11.73	12.82	14.20	16.02	17.56	18.12	20.23	22.91	25.12	28.34	32.10	33.20	35.82	39.62	39.83	NA	NA
	2.b	2,161	2,435	2,661	3,018	3,258	3,373	3,565	4,009	4,425	4,859	5,347	5,404	6,367	6,862	6,010	NA	NA
	3.	5,428	5,265	5,336	5,308	5,390	5,372	5,675	5,715	5,677	5,832	6,003	6,144	5,626	5,774	6,627	NA	NA
France	1.	11.64	12.30	13.04	14.15	15.10	15.70	16.47	17.47	18.49	19.88	21.25	22.63	24.80	27.04	26.96	27.79	29.83
	2.a	26,092	26,905	28,834	31,123	33,047	34,819	35,400	37,523	42,399	46,568	54,490	58,670	64,580	69,500	66,030	68,790	NA
	3.	446	457	452	455	457	451	465	466	436	427	390	386	384	389	408	404	NA
Germany	1.	15.84	17.02	18.17	19.15	20.21	20.65	22.03	22.00	23.40	25.21	27.88	30.31	31.94	32.88	31.16	32.96	34.46
	2.a	21,167	23,247	25,580	27,655	29,717	32,880	34,300	33,380	36,920	43,570	49,190	51,670	52,330	51,900	49,260	54,910	60,320
	3.	748	732	710	692	680	628	642	659	634	579	567	587	610	634	633	600	571
Italy	1.	6.78	7.70	8.75	10.06	10.97	11.70	12.51	13.43	14.73	15.77	16.79	17.53	18.50	19.52	19.09	19.13	18.34
	2.b	1,595	1,801	2,009	2,338	2,258	2,372	2,700	3,150	3,337	3,639	3,992	4,287	4,562	4,730	4,565	4,576	4,830
	3.	4,251	4,275	4,355	4,303	4,858	4,933	4,633	4,263	4,414	4,334	4,206	4,089	4,055	4,127	4,182	4,181	3,797
Neth.	1.	2.81	3.01	3.30	3.59	3.91	4.22	4.49	4.89	5.23	5.64	6.24	6.60	7.07	7.45	6.98	NA	NA
	2.a	6,007	5,796	6,015	6,315	6,674	7,063	6,995	7,432	7,964	8,213	8,838	9,031	8,806	9,154	9,575	NA	NA
	3.	468	519	549	568	586	597	642	658	657	687	706	731	803	814	729	NA	NA
Sweden	1.	2.87	3.10	3.22	3.45	3.78	3.97	4.15	4.13	4.45	4.73	4.93	4.87	5.06	5.39	5.23	5.46	5.65
	2.a	7,527	7,692	7,738	8,052	8,380	8,270	8,270	8,877	9,411	9,783	9,726	9,016	9,661	10,481	10,530	9,053	9,094
	3.	381	403	416	428	451	480	502	465	473	483	507	540	524	514	497	603	621
U.K.	1.	21.11	21.83	21.59	21.83	22.37	22.60	23.00	23.78	24.76	25.57	26.81	27.87	28.95	30.84	29.73	29.37	30.46
	2.a	2,567	2,532	2,650	2,862	3,103	3,114	3,238	3,434	3,605	3,618	3,842	4,228	4,746	4,853	4,396	4,324	4,460
	3.	8,224	8,622	8,147	7,628	7,209	7,258	7,103	6,925	6,868	7,067	6,978	6,592	6,100	6,355	6,763	6,792	6,830

SOURCES: OECD, National Accounts of OECD Countries, Paris, various editions.
OECD, Energy Balances of OECD Countries, Paris, 1976 and 1978 editions.

NOTES: 1. Energy used (mtoe)
2. Output (a million or b billion of local currency)
3. TOE ÷ output

TABLE A.8

TRANSPORT SECTOR: INDEX OF ENERGY USED PER CONSTANT 1970 OUTPUT
(local currency)

Country	1960-1965 Average Ratio	Index	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76
Canada	3,401.30	100	100	101	101	103	115	106	102	97	98	97	93
United States	3,640.16	100	100	103	101	100	105	101	98	96	102	104	96
Japan	5,349.83	100	106	107	106	109	112	115	105	108	124	NA	NA
France	453.00	100	103	103	96	94	86	85	85	86	90	89	NA
West Germany	698.30	100	92	94	91	83	81	84	87	91	91	86	82
Italy	4,495.83	100	103	95	98	96	94	91	90	92	93	93	84
Netherlands	547.83	100	117	120	120	125	129	133	147	149	133	NA	NA
Sweden	426.50	100	118	109	111	113	119	127	123	121	117	141	146
United Kingdom	7,848.00	100	91	88	88	89	89	84	78	81	86	87	87

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